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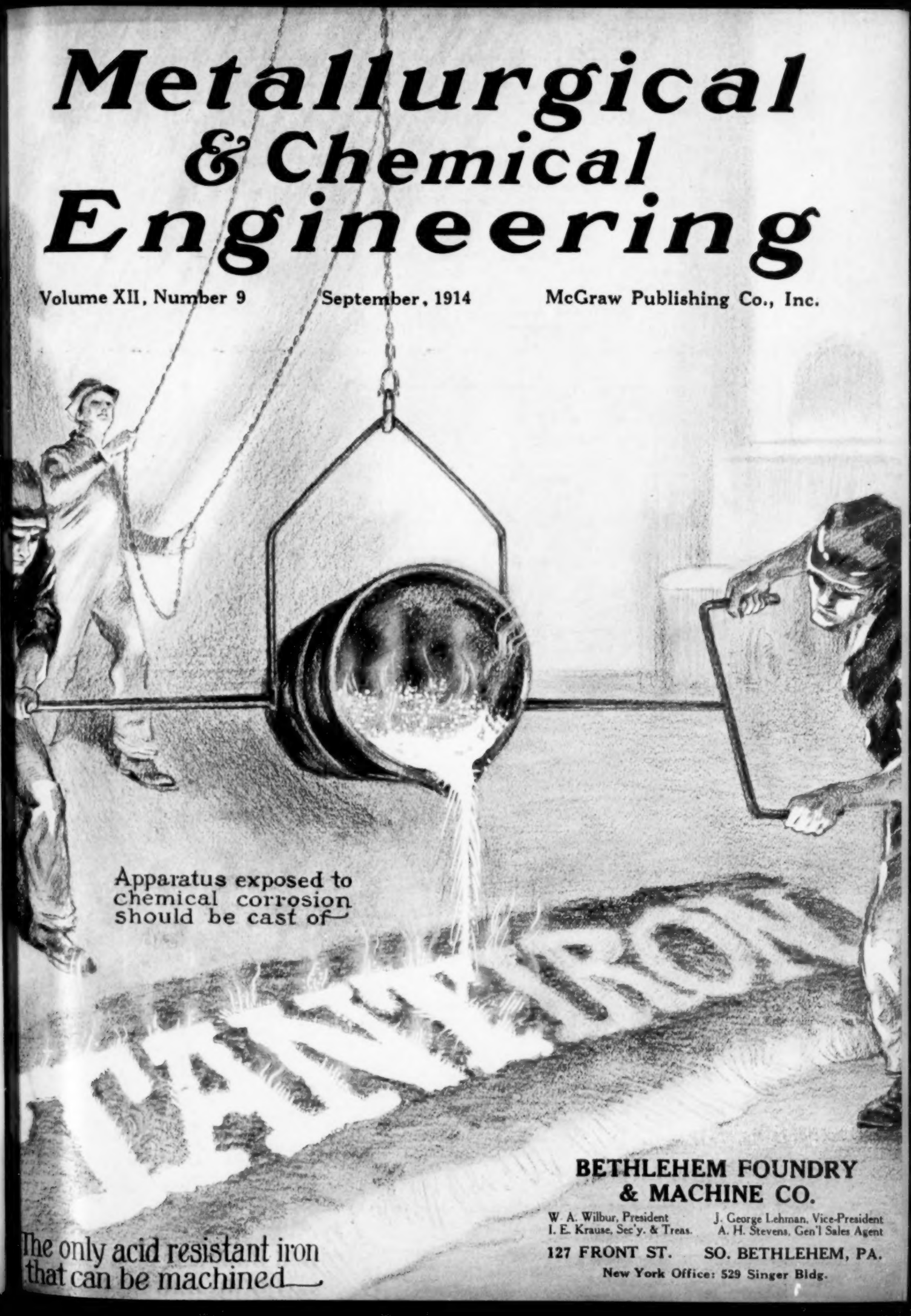
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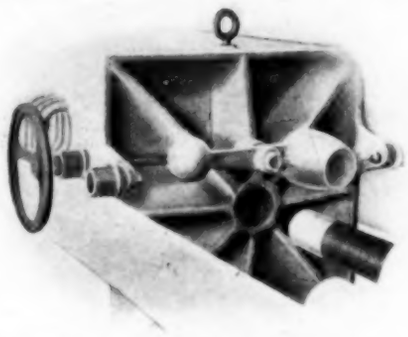

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The European War

War is hell. Our knowledge of what is happening on the other side of the Atlantic comes to us through a rapid sequence of extra-editions of newspapers and while this highly excitable moving picture show of glaring headlines, more or less contradictory, passes before our eyes, we see only one thing clearly—that a gigantic calamity has come over Europe—and we pause quietly to ask why this whole terrible thing is going on.

Have men whom we have known intimately for years and have admired for their peaceful achievements in arts and sciences, suddenly gone crazy? Have practically all Europeans suddenly gone crazy? If we want to avoid this conclusion, nothing is left but the inference that the psychology of nations is different from the psychology of individuals.

Nor is this inference unwarranted. We know that an individual acts differently in a crowd than when left to himself. We know that we may be impressed quite differently by a silver-tongued orator if we hear him in the midst of a sympathetic crowd than when we read his sophisms in the quiet of our home. And when in the past the Devil wanted to try a particularly interesting human reaction, he created a boom in a mining camp. Mark Twain has sketched vividly how the actions of otherwise perfectly sensible and normal men become abnormal in a mining boom. The fact is that when crowd psychology of which national psychology is a variety, gets the best of individual psychology, the "free will" of the individual is gone; there remains not much more of it than the "mean free path" of an atom. Crowds and nations then act under the blind forces of Nature. In the gigantic human reaction which the European war represents, the most celebrated individualities do not seem to have much more freedom of will than the "free" ions of the dissociation theory. And this is the most terrible thing in the situation, because if it is so, it means that the thing must go on to its most brutally complete conclusion.

There are clear-cut reversible chemical reactions. The European war is nothing of the kind. It is irreversible in all its phases and it is a horrid melee of half a dozen or more human reactions so that we cannot say which are primary or secondary—the hatred of race against race or commercial rivalry and envy or a revenge idea or an excess of militaristic autocracy or what else. We only know with absolute certainty that because it is an irreversible reaction its outcome is determined by the second principle of thermodynamics. Whatever may be the detailed result of the war for this or that country or nation, in the whole there must be a frightful increase of entropy. That is, European civili-

zation as a whole must be reduced from a place in the sun to a temperature much nearer absolute zero.

* * *

The more carefully these reactions are restricted to Europe as an isolated system, the better for the rest of the world. President Wilson has been happy in defining the function of this country. There is no cause for alarm, but an opportunity for this nation to reap great permanent glory provided nobody loses his head. Our opportunity does not lie in war but in a control which will fit us, above of all nations of the world, to act for peace when the time comes.

How greatly this country is affected by the European war, is clearly evident in the situation of the metallurgical industries. We may simply look at the two extremes, copper and zinc, the former being hit hard, the latter being benefited by the war.

Half the copper output of this country has been exported in the past. Accordingly the copper production of this country has been cut in half by mines and refineries. While this was undoubtedly the wisest thing to do it means an irrecoverable loss of interest on half the plant investment.

On the other hand, zinc has been put in an enviable position by the fact that the zinc smelting centers of continental Europe are in the zone of war operations. Liege has been for zinc what Pittsburgh is for iron. Our opportunity to export zinc and galvanized iron products to South America is evident. The opportunity of electric zinc smelting is also clear. Our friend, Woolsey McA. Johnson, the American pioneer in this field, has been a brilliant writer on the subject and a clever experimenter in the past. The psychological moment has come for him and his people to deliver the goods in their projected plant at Keokuk.

As to the effects of the European war on the chemical industries of this country, the President's safe and sane advice—to keep a level head on our shoulders—is also the keynote of our interview with Dr. William H. Nichols published elsewhere in this issue.

If American chemists follow this advice, there is a great mission ahead of them. It would seem that the primary endeavor of the American chemical industry should not be so much a search for new markets (though this side of the situation should not be neglected), but a vigorous effort to assist general industry in this country to accommodate itself to the changed conditions. The substitution of glucose for sugar for part of its uses and other instances mentioned by Dr. Nichols show the possibilities ahead of the American chemists.

What enormous adaptations will have to be made in the way of using other materials or means to replace those no longer at the disposal of home industries, it is even yet very difficult to discern. But unless the chemical industry throws its whole efforts into the co-operation, it will find in the already threatening restriction of general industry its own bitter retribution.

On the other hand, the industries consuming chemicals must also keep a cool head. Already there has been too much buying; and even in products in which there is no reason to anticipate the slightest shortage, ignorant and thoughtless attempts to lay in unnecessarily large stocks have resulted in absurd increases of prices.

In other cases it will be necessary to recognize and provide for the total impossibility to obtain certain products on which our industries have come to rely, and it becomes essential to search for substitutes. Naturally those industries which have already provided themselves with chemical staffs and research facilities will be the most successful in finding quickly substitutes or developing means of doing without altogether.

It is, however, unfortunately to be feared that a very large number of lines of manufacture will probably have to depend upon the chemical industry for advice and technical assistance. Though we are confident that this assistance and advice will be cheerfully and even enthusiastically given, it surely will in many cases look like heaping coals of fire on heads which have too often treated the chemical industries of this country with scant consideration.

As Seen After Twenty Years

A prominent metallurgical engineer visiting this country after an absence of almost twenty years said to us recently that one of the great changes he observed in his travel through the United States was the frankness of metallurgists in discussing their technical problems, and their generosity in making public the data on experimental and routine work. The former reticence, noticeable twenty years ago, has almost disappeared. The empirical "secrets of the trade" are no longer valuable, having been displaced largely by exact technical knowledge and skill. As we have advanced beyond the "muscular metallurgy" of the early days of smelting, so have we broadened our conception of self-interest to embrace the welfare and progress of our neighbor.

Another change observed by our visitor, in marked contrast to conditions two decades ago, is the great increase in the number of trained workers in our metallurgical works, and the moral and financial support given to experimental and research work by operating concerns. To-day technical graduates are found in many positions formerly held by untrained men. The foreman or boss of twenty years ago, whose chief claim to ability and distinction in many cases was physical prowess, is now supplanted by the "educated cuss" who, if physically less awe-inspiring and commanding, is mentally abler to relieve his superiors of attention to technical details. And so on down the line.

A third observation of favorable comparison between present and former conditions in the metallurgical industry is the growth in size and influence of technical societies, and the service rendered to the profession by engineering magazines. Owing to world-wide facilities for communication and dissemination of knowledge, this is a feature of our progress easily appreciated by our visitor without making a trip to scenes of former activity. Returning after many years spent in a foreign land, he finds that through such agencies, particularly those of the United States, he has been able to overcome the possible handicap of isolation.

It would be difficult indeed wholly to separate cause

from effect in this wonderful change and improvement. Schools, societies and magazines have stimulated improvement and encouraged progress; at the same time they have been beneficiaries of the conditions they sought to create. Encouraged by the prospect of employment in a dignified and honorable profession, young men have crowded our schools of mining and metallurgy, later joining the great body of engineers who simultaneously support and receive inspiration from technical societies and magazines. The proud eminence which American metallurgy holds to-day is broadly the result of action and reaction among these great co-operating influences.

Scrap and Finished Steel Production

At intervals since early in the year statistics of production in the various branches of the steel industry in 1913 have been returned by the Bureau of Statistics of the American Iron and Steel Institute and have been discussed in these columns. In the past month the last of the 1913 statistics have appeared, detailing the production of bars, skelp, nail plate, etc., and permitting a statement of the total rolled steel output for the year. The presentation is of interest by reason of the comparison that can be made with the total production of steel ingotts, showing the loss in manufacture and thus indicating approximately the amount of scrap resulting. The statistics of rolled steel are complete, covering the weight of material after the last hot rolling operation (with shearing), and thus taking cognizance of rods rather than of rod billets or drawn wire, black plates rather than either tin plate or sheet bars, skelp rather than welded pipe, and so on. Rolled forging billets and exported blooms, billets, sheet bars, etc., are included, as otherwise the material involved would be lost to the statistics.

The statistics of the production of steel ingots (excluding castings) and of rolled steel, together with the difference and the percentage the difference constituted of the ingot tonnage, are shown in the table below, for the past four years, in gross tons:

	Steel ingots.	Rolled steel.	Difference.	Per cent.
1910	25,154,087	20,939,353	4,214,734	16.4
1911	23,029,479	17,812,823	5,216,656	22.6
1912	30,284,682	23,019,259	7,265,423	24.0
1913	30,280,130	23,112,986	7,167,144	23.7

The sharp increase in the difference between ingot and rolled steel tonnage is remarkable and is probably attributable to a variety of causes, the proportionately greater increase in the production of steel involving many rollings, sheets, and black plates, for instance, as compared with rails, deeper cropping for the purpose of producing sound steel, and perhaps a definite desire upon the part of the steel makers to produce scrap for the open-hearth.

The experience of the past two years may be taken as representative of present-day practice, a loss of 24 per cent in weight from the ingot to the rolled steel. Part of this loss is scale, but by far the greater part is scrap. Very nearly all the scrap passes at once to the open-hearth furnace, to be used again in the production of steel ingots. A small part, doubtless, goes to steel furnaces for the production of castings, but as the production of open-hearth castings was only 910,216 tons in 1913 this item is relatively unimportant. On the other hand, there is new scrap produced in the fabrication of rolled steel, as in pipe mills, structural shops, etc. Estimating as closely as possible, but still roughly, the various additions and deductions, one may conclude that in 1913 about 6,500,000 tons of new steel scrap, produced in steel rolling mills, pipe mills, fabricating shops, etc., found its way into acid and basic open-hearth steel furnaces for the production of steel ingots.

We have statistics of the production of basic pig iron, practically all of this material passing to the basic open-hearth steel furnace, but no corresponding statistics of the production of pig iron for the acid open-hearth furnace, hence no comparison can be made of scrap and pig iron for the open-hearth industry as a whole. On the assumption that proportions were the same, an assumption that can lead to no serious error on account of the relatively small tonnages excluded, it may be concluded that in the production of basic open-hearth steel ingots about 6,250,000 tons of new steel scrap was employed, while the consumption of basic pig iron was about 12,250,000 tons. The production of basic open-hearth steel ingots was 19,884,465 tons, leaving a difference of 1,384,465 tons. This difference represents the consumption of old iron and steel scrap and casting pit scrap, plus the ferric gains through ore additions to the bath, minus slag and other losses. The consumption of old scrap is seen to be quite small relative to the consumption of new scrap, a fact which is not universally recognized outside the steel mill. It will be understood, of course, that the proportions vary widely in different plants. At the duplex works the consumption of old material is very small, while in detached open-hearth steel works, using purchased (cold) pig iron the consumption of old material is quite large. The commonest operation, in point of tonnage, is that of combined open-hearth and Bessemer operations, in which the open-hearth furnace receives not only the scrap produced in rolling the steel it produces, but also the Bessemer scrap arising.

As the production of Bessemer steel has declined the proportion of new scrap available for the open-hearth furnace is necessarily reduced. In 1907 the production of Bessemer ingots exceeded that of open-hearth ingots by 7.5 per cent, but in 1913 open-hearth exceeded Bessemer by almost 120 per cent. There is some evidence, as indicated, that cropping has been more liberal in the past two years than formerly, and this helps to keep up the scrap supply. More recourse is had, in addition, to the duplex process, which does not need scrap badly, but the final liquidation is in increased proportions of pig iron to steel ingots produced, a fact to which reference was made in our August number, it being there estimated that, excluding the duplex steel branch, the consumption of basic pig iron was 54.8 per cent of the steel produced in 1912, and 56.9 per cent in 1913.

Readers' Views and Comments

Electrolytic Zinc

To the Editor of Metallurgical & Chemical Engineering:

Sir:—With regard to your note on the "Borchgrevink electrolytic process for the treatment of zinc ores" in your June issue (page 381) I beg to remark that the invention was not made by Mr. Borchgrevink, but was worked out by the undersigned during a study-trip in Germany. Later on the expenses, with an experimental installation, have been paid for by Mr. Borchgrevink.

If the necessary capital can be procured, the intention is in the autumn to start a greater experimental plant with a capacity of about 85 tons a day.

In this electrolytic process an anode is used which was invented by myself with a special fit-up, which prevents the formation of roughnesses and trees on the zinc. The patent is taken out in Mr. Borchgrevink's and my own name.

R. MOLSTAD.

Christiania, Norway.

Is There a Complex Ore Problem?

To the Editor of Metallurgical & Chemical Engineering:

SIR—In your August issue, page 490, Mr. W. Motherwell criticizes the following remark made by me in your June issue:

"In passing, as there are fads in metallurgical lines as well as in others, I might note that we are going through a stage when the whole fraternity is on the qui vive trying to make every ore amenable to treatment by some flotation process. In the case of one-mineral separation in the United States this process has proven an aid; but it is of no benefit in the case of ores of zinc, which are truly complex, although being advocated for such. I do not know of any complex ore in Colorado, for instance, that could possibly show any advantage under this treatment."

His second paragraph brings out what he imagines is a surprise in that there are four flotation processes used in Australia.

In the third paragraph he states: "It might be worth while to have some experiments made with it," this latter statement referring to Colorado complex ore.

In the fourth paragraph he calls attention to the so-called selective flotation process.

In making the statement shown in his first paragraph I did so advisedly, proof being that only those ventures are a success with flotation which have a one-mineral separation, notably, the Butte & Superior Copper Company and the Elm Orlu at Butte, and a plant down in the Platte River country, Missouri. Of course, there are incidentally small amounts of other than the main sulphides obtained in separation, but these amounts of minerals are not quantitatively sufficient to cause annoyance.

As to his second paragraph, I was well aware of the work that has been done in Australia, as is everyone engaged in the metallurgical field. I referred in my statement only to the work done in the United States.

There is no question but that flotation will be used on the copper porphyries to separate a small amount of mineral from a large amount of gangue and will be used as an adjunct in some large plants having a large percentage of gangue and a small percentage of mineral, notably on the slime product which is a result of crushing, the tonnages here being sufficiently large to permit of one demand of the process—that there is a large enough tonnage to work upon for financial success.

Regarding Mr. Motherwell's third paragraph, I would say that I already have the proof and he admits that he has not. However, to gain his point he must present some facts which are other than surmises. Incidentally I have had the privilege of running thousands of tons of the class of ore mentioned. Our ores, as a rule, are rather coarsely crystalline so that it is not a difficult matter to make a proper separation by ordinary mechanical means, and incidentally I would also say that such ores do not have a large percentage of gangue.

Further, there have been at least two plants in Colorado which have been built to operate by some flotation process, these being more or less experimental on a large scale. There is no tonnage of a smelting grade of zinc blende being produced by either operation and yet the experiments have cost, no doubt, a sum of money sufficiently large to be noticeable.

I myself have had to do with some experimenting on Colorado ores and ores from other states and so far have found it advisable on the truly complex ores to only recommend the flotation process as a subsidiary to the other general operations, that is, where the tonnage is sufficiently large to furnish an amount of suitable material for such operation.

With respect to Mr. Motherwell's fourth paragraph, it would seem as if up to date this selective flotation process was a matter requiring "fine-haired" operating efficiency and also would be very expensive, in which case, by comparison, it would not return as great a net profit to the mine, no doubt, as the ordinary older means of mechanical separation.

Since the proofs of my statements are evident and since Mr. Motherwell does not even admit familiarity with the situation, I would suggest that he furnish proofs against my statements. Otherwise there is no argument.

LEWIS B. SKINNER.

Denver, Colo.

* * *

To the Editor of Metallurgical & Chemical Engineering:

Sir:—Since writing you on this subject I have found time to read Mr. Ionides' contribution in your June issue. He speaks of an ore containing about 5 oz. Ag. per ton, 14.5 per cent Pb., 13 per cent Zn. and 0.25 per cent Cu., and refers to the heavy penalty exacted by the smelters for the zinc.

Assuming the lead and zinc to be in the form of sulphide, any person who would send this kind of ore to a smelter deserves all he gets. The flotation process will, by itself or in conjunction with mechanical concentrators, give him two separate marketable concentrates—one containing the lead and the other the zinc.

The assay given above represents roughly the value of the sulphide ore now being mined at Broken Hill, and not a ton of it is smelted in the crude state, and has not been for at least fifteen years. Before the flotation processes were used on a commercial scale, ten years ago, the ore was concentrated by jigs, tables and vanners, the lead and some of the silver recovered, and the tailing containing the zinc and some lead and silver was accumulated pending discovery of a method of treatment.

I should perhaps have explained in my previous letter that the complexity of Broken Hill ore arises, not so much from its metal contents, as from the nature of the gangue which is largely composed of rhodonite

and garnet, which have about the same specific gravity as blende.

Further on, Mr. Ionides says: "No instance is known to me where high recoveries of all metals are made from an ore containing lead and zinc, copper and zinc, or all three." At the Broken Hill South mine during the second half of 1913 (according to the *Mining and Scientific Press* of May 9, 1914), the total extraction was 91 per cent lead, 85.6 per cent silver, and 84.2 per cent of the zinc. What has Mr. Ionides to say to that? The recoveries at some other Broken Hill mines (Proprietary, North and Central) are about the same.

He also says "the shine product from a lead or copper ore certainly is refractory." This was true ten years ago, but to-day nothing is easier. The same may be said of his remark that "the presence of zinc in an ore gives trouble all the way down the line, and if recovered with the lead it becomes a liability and not an asset."

His objection that flotation will not separate two minerals, I have already answered in my previous letter.

It appears to me that the possibilities of flotation are not fully realized in this country.

W. MOTHERWELL.

Humboldt, Arizona.

* * *

To the Editor of Metallurgical & Chemical Engineering:

SIR:—If we admit that the fine-grained ores composed of lead, zinc, and copper sulphides which have hitherto not been successfully treated on a commercial basis—excepting for the recovery of one metal—are "complex" ores, then there *is* a complex ore problem.

Some few years ago I went down to Cardigaushire, Wales, to examine a concentrating mill and tailings from same and ore from the mine. I found stacked a quite big pile of "seconds" from the tables which assayed Cu 7.5, Pb 11.8, Zn 25.5, Fe 9.9, S 28.5, CaO 5.6. The CaO was due to calcite gangue. There was no complex ore here, however, as in the mine a hand separation could have been made. I sampled a 6-in. vein of blend carrying 64.5 per cent Zn and the Pb occurred as 3-in. vein pure galena. The copper and iron were associated.

Such ores as of the Hercules-McRead district of Tasmania I would call "complex" and their successful treatment still awaits solution. Typical "Hercules" sulphide ore from No. 5 level: Cu 0.3, Pb 10 per cent to 12 per cent, Zn 26 per cent to 30 per cent, Fe 11 per cent, Mn 1.5 per cent, S 30 per cent, insoluble 10 per cent.

A really fine example of an ore worthy of the name "complex" is to be found in that probably forgotten mine, "Lake George," N. S. W., where such brilliant smelting work was done in 1899 by A. W. Hudson, now in Douglas, Arizona, a 27 per cent copper matte at first fusion being made from an ore under 2 per cent copper. At the 400-ft., 500-ft. and 600-ft. levels the ore body is about 40 ft. wide and every pound of it goes to the smelter. It is one of those close-grained sulphide ores in which no distinguishable minerals are visible. A government analysis of the 400-ft. level ore gives: Cu 1.1 per cent, Pb 8.0, Zn 14.5, Fe 17.7, SiO_2 23.7, CaO 0.4, MgO 0.65, Pb So_4 0.32.

My analysis of the "bulk ore" as sent to the furnaces towards the end of the smelting campaign runs: Cu 1.25 per cent, Pb 9.7, Zn 13.2 Fe 22.2 $SiO_2 + Al_2O_3$ 21.5, CaO 1.6, S 29.5.

This was sweetened up with some ores from upper levels and adjoining mines, one example being Cu 5, Pb 11.5, Zn 18.6, Fe 15.7, insoluble 17.2, CaO 0.5, S 29.5. There is a chance for the lead and zinc experts.

As other examples of what may be called complex ores I would mention those of the Conrad district of New South Wales, Bethanga and Cassillis districts of Victoria and the Oonah of Tasmania.

Mention of the Lake George mines reminds me in view of the present boom in leaching and recovery by scrap iron that it may not be known that as far back as 1899 many tons of copper were recovered from this mine from mine water. A much greater recovery might have been made had the management been awake, but the chemist's importunities were futile until backed up by threatened action for the loss of a cow that died from drinking the water 1 mile below the mine; and also a general outcry from the inhabitants of the township, whose water supply—drawn from wells sunk near the creek—gave a pale green shade to all clothes on washing day. That water carried 250 gr. per gallon.

H. MOTHERWELL.

Inspiration Cons. Copper Co.,
Miami, Arizona.

Cost Accounting as a Branch of Accounting, and the Work of Accountants

To the Editor of Metallurgical & Chemical Engineering:

SIR:—Mr. Justin H. Haynes' article in your July issue regarding unit cost keeping in metallurgical work is deeply interesting. He emphasizes "that the cost statistics and cost sheet are a comparative guide to the maintenance of efficiency in a plant controlled or supervised by any executive."

This is the traditional and accepted definition of a cost sheet, and accountants universally are striving with considerable measure of success to make it so, and to make the figures that are placed thereon the true and actual showing for any period under review.

As I am in opposition to Mr. Haynes, as to who should draw up costs accounts, I would like to place before him through the pages of your paper Cost Accounting from the Accountant's standpoint and to show the necessity to *both the operator* and the administration, of the cost accounts and the fiscal books being in unison. This I will try and do, also endeavoring to convince him that the accountant is the most necessary friend of the operator, both in translating his desires and in placing before him those figures and statements which will furnish him with all the true figures that are requested of him, and which will also be in perfect harmony with the financial section of the company's books.

My views are:

Cost-accounting records, though perhaps only indirectly related to bookkeeping records, must be founded on ordinary double-entry principles. It may be sufficient for the financial records to show the total amount of the payroll, for example, whilst for the superintendent's cost sheet this item on the financial books will have to be dissected, and in consequence of obtaining this dissection from the financial records it will be a detail of these financial records. In other words the cost accounts must be in concord with the financial records, if for no other reason than the double check it affords both systems (and in consequence the greater security the operating man can feel in reviewing his figures).

Further cost keeping must be part and parcel of the whole accounting system for the reason that both use data that are alive in both. For whilst financial bookkeeping generally considers the operations of an organization, cost accounting considers the operations in detail. Both have to do with resources, liabilities, receipts, disbursements, losses and gains. And the fact that all these headings enter into both cost accounting and financial book-keeping, and that the former will have to look to the latter for its division of same shows

only more clearly that it is impossible to draw any distinct line between them. They are an entity.

The man to advise and install a system of cost accounts should be a technical statistician who understands and studies the requirements and methods of manufacturing, etc. This the members of the accounting profession are rapidly becoming more and more to be.

In this installation, accountants readily recognize that it is most necessary for the cost systematizer to cooperate with the engineer if an efficient and practical cost system is to result. Obviously a superintendent knows along what lines he wishes information, and as the results are of primary importance to the engineer, that person should suggest these lines; but the accountant is the better suited to determine the means, the procedure and forms in connection with acquiring these data, as well as of distributing and segregating same, inasmuch as it is the accounting profession and not the engineering profession that has concerned itself with the study of cost systems together with their many deep and vexed problems (operating expense burden being an example). This study of cost accounting by accountants has not been given for the purpose of giving information to directors (excepting where a problem of cost accounting attaches itself to the desire of directors to test the efficiency of the superintendent or his subordinates), but for the purpose of giving the superintendent the benefit of a more scientific interpretation of the proper division and application of certain facts.

I would lay strong stress on the parenthesis above, to draw out the fact that the operator is not the only one interested in his cost figures, but that his executive is also so interested, when the accountant, who is independent of the operator, vouches for the figures shown, they will certainly have more weight than if the operator makes them up in his own way, and if they are diversant from the financial or accountant's books.

The degree of finesse to which any cost system can be installed is determined by the wishes of the superintendent, but it should be also determined by experience. Expense is also often a consideration.

If (as doubtless it will be, where applicable) the unit cost system is desired, it could be and has been as readily installed in stamp milling as it has been used elsewhere, in flour mills, cotton mills, steel mills, railroads and public utilities, etc., by accountants.

To say that the accountant is not interested in the unit cost, is to exaggerate slightly. It is his duty to be interested in that, and in any other thing in the line of accounts that any individual requires. And further, as the unit cost is determined by the "dollar and cents" costs, he will undobutedly have an endless chain of interest as long as costing is the subject.

An example of how the accountant is interested in the operating figures and the financial figures at the same time is this: Assume a milling company purchasing various parts of machinery, to be installed, worth say $1000. The operator having no books is compelled to write it all off in his cost sheet in the first month, instead of being able to open a "suspense account" and proportion this charge reasonably over the proper life of the machinery. Inasmuch as this will affect the profit and loss account of the company in the month it is written off, and also in the subsequent month it should have been written off, it is interesting to the financial end, more especially as the possibility is that with a large concern, the $1000 item mentioned above will be manifoldly increased.

In fact in many more ways than this the operator (if unattached to the financial department of the concern) can be responsible for unreliable statements of the company, as well as cost sheets that would deceive himself.

I think the particular reason that poor results are often obtained, is the fact that many engineers are too prone to belittle the intelligence of the accounting department, and to consider this department as "only a necessary expense to be kept as low as possible," and that they therefore are too ready to employ cheap material instead of obtaining men with experience, training and intelligence in cost accounting. Mayhap Mr. Haynes has been in environments of this character, and it is to be regretted that this state of affairs exists.

It should be the keynote of both the engineering and accounting professions in regard to cost keeping, to submerge their own and their departmental antagonisms, and co-operate in a friendly business way to both design and carry out costing to the beneficial health of the whole corporation of which they are units.

The operator may feel that "errors are creeping into the very foundation" of his data, and "that exact distribution is unobtainable." This can certainly be remedied by his getting together with the accounting department and co-operating with them to put in the proper forms and system that will give him absolutely reliable information.

The cuts that Mr. Haynes has displayed are interesting as examples of what are especially adapted to his requirements, but are only synonymous with like information obtained from systems installed universally by accountants.

In conclusion, I would say, that the field of cost accounting is so broad and varied that it behooves all of us to broaden our viewpoint and knowledge for the betterment of all concerned, and it is treason to intelligence to infer that a chemist (for example) can have knowledge of chemistry and nothing else, or an engineer of engineering and nought else, etc., etc., or that nobody else can be of use to him even in his own sphere. He should rather be prepared to interest others in his work. Only with a viewpoint of unity can it be possible for the executive-in-charge to arrive at the best reliable information regarding the cost accounting placed before him—that is by the joining of the ideas of the accounting and engineering staff, and the relating of the costs to the financial records.

ERNEST G. ASHBY.
Accountant, Cyanide Plant.
Alaska Treadwell Gold Mining Co.,
Treadwell, Alaska.

Toronto Meeting of American Chemical Society Postponed

The meeting of the American Chemical Society which was to be held in Montreal, Canada, in September, has been indefinitely postponed on account of Canada being involved in the European war, and it now seems improbable that any meeting of the Society will be held this fall for the reading of papers. The present outlook is that the next meeting of the American Chemical Society will be in New Orleans, April 1 to 3, 1915.

The **American Foundrymen's Association** and the **American Institute of Metals** will hold the annual meeting in Chicago from September 7 to 11. The program of the American Institute of Metals comprises joint meetings with the American Foundrymen's Association on Tuesday and Wednesday, 10 a. m., and separate meetings on Tuesday, 2 p. m., Thursday, 10 a. m. and 2 p. m., and Friday, 10 a. m. On Monday evening the Foremen hold a banquet at the La Salle Hotel, and on Thursday evening the American Institute of Metals holds a meeting at the same place.

The European War and the Chemical Industries of This Country

The European war is affecting the chemical industries of this country in the most varying phases. To get a clear view of the situation, METALLURGICAL AND CHEMICAL ENGINEERING has interviewed a few men, prominent in American chemistry. To serve as a general guide the following questions were asked:

1. How does the cutting-off of the supply of certain raw materials by the European war affect the continuity of operation of the various chemical industries in this country? Can any of these raw materials be procured in the United States so as to make our industries independent of other countries? What is the situation of the potash industry?
2. Will the forced industrial restriction in Europe, if it continues long enough, warrant the development in this country of chemical industries which have so far been almost exclusively European? What are the possibilities of an American coal tar industry?
3. In the case of a long continued war, do you think that the personnel of the American chemical and metallurgical industries will be affected? Do you think it possible that there may be a scarcity of chemically trained men or of unskilled workmen?
4. Is there enough demand in South American countries for products of the chemical industries to make exports from this country worth while and open new markets for the chemical industries of this country?

* * *

Interview with Dr. Wm. H. Nichols

CHAIRMAN OF THE BOARD, GENERAL CHEMICAL COMPANY; PRESIDENT, NICHOLS COPPER COMPANY; PAST PRESIDENT OF THE SOCIETY OF CHEMICAL INDUSTRY; AND PRESIDENT OF THE EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY, 1912.

In an interview given to the Editor of METALLURGICAL AND CHEMICAL ENGINEERING on August 21, Dr. Wm. H. Nichols stated that at the present moment no one is in position to arrive at definite conclusions concerning the effect on this country of the European war, as conditions are rapidly changing day by day, and past events have given us very little on which to base present conclusions. He emphasized the fact, however, that we had certainly learned that it was unnecessary for the American business man to worry; that patience and calmness would be amply repaid in the better frame of mind in which the Americans would approach the thousands of new problems which are constantly arising, and which will, of course, have to be solved.

The European war will put the American chemist on his mettle, and he will certainly arise to the emergency and demonstrate that he is made of the right stuff.

In reply to the four specific questions given above, Dr. Nichols stated as follows:

1. The supply of raw materials, as far as the field of heavy chemicals is concerned, would appear to call for no alarm and comparatively little uneasiness. Pyrites, nitrate of soda, and material of that kind, though coming largely from Spain, South America and other foreign ports, seem to be arriving with considerable regularity, and should not seriously jeopardize those chemicals used in the manufacturing of the first chemical raw material. Stassfurt potash supply, upon which the world depends, is, of course, entirely cut off. The American farmer may have to get along for the time being without potash fertilizers; but other substitutes will take their place for the present. Potash for other industries used in smaller quantities may be secured from sea weed or feldspar. Necessities will develop other sources of supply than the German mines. With the chemicals that this country has depended upon Germany supplying, covering a wide range from certain salts, such as epsom salts made from kieserite, which industry Germany has entirely stifled in this country, through to finished dyes, which have never been made in quantity outside of the large German factories, it is too early to state what America will do; but it is safe to say that most of them we can get along without when necessity dictates.

2. The prospect of the American coal tar industry will depend very largely on the encouragement which the American buyer will give to the American manufacturer. The experience of the Benzol Products Co., which started in a small way to manufacture aniline oil in this country, illustrates the attitude that Europeans have always taken where Americans have tried to parallel their manufacturing experiences. They decided that the American plant must be killed off, and although a tariff of 10 per cent was placed on aniline oil by the Democratic Congress, foreign manufacturers reduced the price to a point where it was impossible to compete. It has heretofore been found impossible to secure encouragement for certain lines of manufacture here from the buyer of chemicals, and it is largely through the desire of the American purchaser to secure his goods at the lowest possible price that the color industry has not been able to get a foothold. The development of this branch of the chemical industry is, therefore, entirely in the hands of the buyers, and no manufacturer can predict what is likely to come out of the present curtailment of imports of necessary chemicals to this country.

3. A scarcity of trained chemists or unskilled workmen seems to be at the present time entirely out of the question, although it is, of course, hard to foresee what technical knowledge will now be called into use.

4. The South American market for chemicals is an important one, and though it is not yet developed, it may be expected to grow into an important outlet for American products. The difficulties of doing business in South America has largely been caused by lack of proper banking facilities, and it is only after this problem is solved that we may turn to the Southern republics as large consumers of our products.

With regard to the copper market, he stated that the situation was quite remarkable, and that the producers had for the first time in their history been unanimous in showing a large amount of common sense. All copper mines had reduced production by 50 per cent or even more and the refineries had, of course, followed suit, the Nichols Copper Company plant being run at present at about 50 per cent of its capacity. As, approximately, one-half of the copper produced has heretofore gone abroad, this curtailment should make it possible to provide for all of the local requirements, so that when the war is over the metal should be in a good and strong position.

He again emphasized that in this crisis the American copper men have shown more sense than ever before, and that they had been absolutely unanimous.

In summing up, Dr. Nichols took a very reassuring view of the whole situation. He admitted that it would be necessary to readjust ourselves to new conditions, but that in his opinion American ingenuity will solve most, if not all, of the problems as they arise.

He gave as an example of American resources—the sugar situation. As the price goes up, glucose or corn syrup will take its place in many fields. Glucose cannot, of course, replace granulated sugar, but it most

certainly will add a cheap substitute for sugar in many household uses.

The interruption of the shipment of jute to this country had also called for the ingenuity of the American manufacturers, who are in some places replacing rough cotton bags for the heretofore indispensable jute bags.

He considered that there would be no danger of lack of necessities of life, but that the extravagances of the last few years might have to be restrained.

It would appear from our interview that Dr. Nichols considers this a great opportunity for the American chemist to show what he is able to accomplish.

* * *

Another Reassuring View of the General Situation

Mr. **Maximilian Toch** (partner of Toch Brothers) remarks that since the war was declared his firm has been working night and day, and he is of the opinion that this is the finest opportunity that America has ever had for the development of her chemical industries.

1. The cutting off of supply of certain raw materials will, of course, cripple the chemical industries for the time being. There is no doubt that matters will right themselves, because we are more or less of a pioneer nation, and a pioneer can always help himself. In the case of raw materials, it would be difficult to say exactly how many of the raw materials can be procured in the United States which were formerly imported. Of course, indigenous raw materials cannot be made excepting in the country where they are grown or procured, such as the fossil resins. Still, we are able with the aid of China wood oil and resin to do many things we could not do 10 years ago, but China wood oil, in case our supply is cut off, could be produced in time in America, for the Department of Agriculture, through the able work of David Fairchild, has planted a number of Kiri nut trees.

As regards the potash situation there are a number of methods for the extraction of sufficient potash from felspar, kelp and the like. Many of the methods, some of which are patented, have never been exploited on account of their cost, but for the present cost will not enter, and therefore we should have no fear that the supply of potash will be curtailed if we can make a sufficient quantity from many of the potash-bearing materials in the United States.

2. The forced industrial restrictions in Europe, whether they continue long enough or not, by all means warrant the development in this country of many of the chemical industries which we have slighted in times gone by. With the exception of the patented coal tar colors, Mr. Toch sees no reason why all the others should not be made here, and as near as he can glean, two concerns are already starting in to erect installations for the purpose of making many of the coal tar colors which have heretofore only been made in this country on a small scale.

3. "I do not consider that there will be a scarcity of chemically trained men or skilled workmen in the case of a long continued war. Opportunity always brings out the best that there is in us, and in my own case I have advanced some men owing to sudden increased business and feel that they will fill the positions capably.

4. "There is a sufficient demand in South American countries for the products of the chemical industries to make exports from this country worth while. In the paint, varnish and chemical industry very few materials have ever been exported to South America. It is just three weeks ago since hostilities became general, but within the last three weeks our firm has received two substantial orders from South America from a district where English and German competition has prevented us from selling."

* * *

Interviews on the Coal-Tar Industry

Mr. **William J. Matheson** (president Matheson Lead Company, vice-president Corn Products Refining Company, director American Cotton Oil Company, Benzol Products Company, Cassella Color Company, General Chemical Company) comments on question (2) as follows: "In regard to the organic chemical industries, especially the primal products, such as aniline oil, aniline salts, beta naphthol, paranitro aniline, etc., the industry is already developed, and its growth depends in large measure upon the supply of cheap benzol. These products are made by the Benzol Products Company.

"As to coal-tar colors or dyes, I would not attempt to add to the able paper* that has been presented on this subject by Dr. Hesse."

* * *

Dr. **B. C. Hesse** (chemical engineer and expert, 90 William Street, New York City) comments on question (2), with special reference to the coal-tar industry, as follows:

In the coal-tar industry the following three divisions may be made for convenience and clarity:

I. Products from coal-tar by distillation, expression and like operations.

II. Products obtained from I by chemical transformation but not themselves dyes.

III. Dyes made from II.

I and II make up practically all of paragraph 536 of the United States Tariff of 1909.

According to what purport to be official German figures Germany's foreign trade in 1913 in these three classes was as follows (in metric tons):

	Imports into Germany	Exports from Germany	Excess of Exports over Imports
I	67,501	342,893	275,392
II	673	16,311	15,638
III.....	3,238	163,874	160,636

Obviously division I need not be further considered. As to division II the German figures are given in three subdivisions:

(a) Anilin oil and salt.

(b) Naphthol and naphthylamin.

(c) Anthraquinone, nitro-benzol, toluidin, resorcin, phthalic acid and other coal-tar products.

For division III the German figures are given in four subdivisions:

(d) Aniline dyes.

(e) Anthracene dyes, other than Alizarin red.

(f) Alizarin red.

(g) Indigo.

At present the United States produces about 30 per cent of its requirements of aniline dyes (division III), but almost entirely from materials of division II brought from Germany.

The key to the situation lies in division II and in this Germany controls the world's markets. This control is due to the facts that while the growth of this division was relatively slow, yet the field has become very much interwoven, each of its hundred or more products are dependent upon or made up of one or more other products, no one of them is of use without still others; the industrial and commercial conditions or relations have grown with the technical development so that the coal-tar dye industry is really a conglomerate of many separate parts acting and reacting upon each other, commercially and industrially.

*This paper is printed on p. 584. See also the following interview.—EDITOR.

Not a single one of the 22 factories in Germany is wholly independent of other factories in Germany, whereas together they are independent of sources outside of Germany, or can very readily be so should occasion arise. It would not do merely to transplant even the largest German works to this country; a part of probably each German works would be necessary to produce here or anywhere a complete and self-contained industry. Such a transplanting of the coal-tar dye industry would be comparable to an attempt to transplant to this country *every single branch* of, say, the textile industry or any other highly ramified and diversified art.

Germany's supremacy in this field has been for more than 30 years a standing challenge not only to the chemists and capitalists of the United States but to the chemists and capitalists of all the rest of the world as well. Except Switzerland, no country has succeeded in selling Germany more coal-tar dyes than it buys from Germany, but all of them *without exception* buy more of intermediate products, i. e., division II, from Germany than they sell Germany.

The seven European countries other than Germany noted for their chemists and having a large and flourishing chemical industry are Austria, Belgium, France, Great Britain, Italy, Russia and Switzerland. Their indebtedness in metric tons to Germany, together with that of the United States, for 1913, the countries being arranged in the order of their total indebtedness which is distributed over the seven items, follows:

	Division II			Division III				
	a	b	c	d	e	f	g	
	Anilin Oil	Naphthol and Naphthylamin	Anthra Quin. one, etc.	Anilin Dyes	Varicolored Alizarins	Alizarin Red	Indigo	Net Totals
1. United States	2,428	638	965	13,855	2,164	493	3,461	24,004
2. Great Britain	340	333	**34	10,793	1,130	1,493	1,180	15,235
3. Austria	655	109	284	5,582	**223	207	1,361	7,975
4. Italy	650	....	825	4,097	158	....	662	6,392
5. Russia	602	1,117	998	1,098	156	174	434	4,579
6. Belgium	120	....	108	2,400	96	....	313	3,037
7. France	....	217	776	1,301	124	98	323	2,839
8. Switzerland	1,217	272	1,261	**941	....	259	....	2,008
Net totals	6,012	2,686	5,123	38,185	3,605	2,724	7,734	66,069
Number of countries Germany exported to	11	6	11	32	12	9	21	

Summarized by divisions II and III the results are:

	II	III
United States	4,031	19,973
Great Britain	639	14,596
Austria	1,048	6,927
Italy	1,475	4,917
Russia	2,717	1,862
Belgium	228	2,809
France	893	1,846
Switzerland	2,690	** 682

**Credit

According to the latest information available the number of coal-tar dyestuff works in the world and their geographical distribution in 11 countries is as follows, in the order of their number of factories: 22 Germany, 11 France, 11 Great Britain, 9 United States, 4 Austria-Hungary, 4 Switzerland, 2 Holland, 2 Russia, 1 Belgium, 1 Greece, 1 Italy.

In the course of the development of this business 16 plants that made coal-tar dyes have abandoned that work, 11 in Germany and one each in Austria, Belgium, France, Great Britain and Switzerland. Fourtenn have been absorbed by others, six in Germany, four in Switzerland, two in France and one each in Belgium and Holland.

Where these seven countries together have failed so signally it cannot be fairly urged as a fault of the chemists of this country that they have not succeeded.

There is another side to this, namely, the investor's side. A self-contained and complete coal-tar dye industry in this country would to-day call for preparedness to make about 700 different dyes. In the fiscal year 1913-1914 this country imported indigo to the extent of $1,093,226, alizarin to the extent of $845,459, both of which are without tariff protection; $7,464,134 worth of aniline dyes with a duty of 30 per cent and aniline oil with a duty of 10 per cent. This means 700 different aniline dyes would average a gross annual income each of about $10,000. To introduce 700 different sets of operations and perhaps half that many different sets of apparatus at *one time* to produce on the average for each set of operations a gross of $35 per day can hardly be regarded as an attractive proposition when the initial lump gross outlay would be not less than $5,000,000 actual cash. Each of these 700 products requires good manufacture from the start because good qualities of each are already on the market. It is one thing to grow and develop such an industry or art and to maintain it against newcomers, but it is quite a different thing to build it up afresh and in its entirety in the face of competition and to hold it against those who developed the business, know all its ins and outs, have their experience and plant bought, paid for and written off long ago. It could hardly be expected that if successful this would employ as many as 7000 people all told and the gross makes out less than 0.4 per cent of our total import business.

With unlimited and immediately available capital the American chemist can build up such a complete industry, but the dividends would be a long way off. Capitalists, American or otherwise, do not take kindly to such handicaps or obstacles, and justly so.

The truth seems to be that the whole of this industry cannot be successfully transplanted and attempts to transplant part only have not resulted in any self-contained and independent industry anywhere but in a thing whose real roots are still in German soil and if it could be transplanted as a whole the net result would not be commensurate with the expense, effort and risk connected with it. What portion or part if any, and the equivalent of a complete and self-contained industry for all the domestic needs of this country could ultimately be transplanted here is a problem that has had the serious attention of competent chemists and capitalists in this country for many years without a definite or satisfactory answer thereto having been arrived at. If the present conditions will contribute to a solution thereof cannot be decided out of hand, the first impression certainly is that they will *not* so contribute.

Dr. **Louis J. Matos** (of the technical staff of the Cassella Color Company) points out that the question is: *Can* aniline dyes be made here in the present emergency, and in sufficient quantity and variety for our mills?

The question is not, primarily, whether we have the necessary complement of those "highly specialized and trained chemists" always connected with the dyestuff industry in discourses, but whether we produce a sufficient quantity of coal tar to make us independent of any foreign source of tar, and also whether higher prices cannot be obtained for certain tar distillates and fractions from commercial outlets other than the color industry could afford to pay.

Immense quantities of naphthalene are consumed here in the form of "tar camphor," and it is probable that much of this is available from tars produced here, and which could conveniently serve as a most valuable raw material or starting product for a most extensive series of dyes of which it is the base.

Lower fractions of the tar distillates, including *toluol*, are undoubtedly produced here, and in this case we have another initial raw material for a wide range of dyes.

Patent matters in connection with the dyes are of great importance, and for the extension of the tar color industry here the expired patents of still useful dyes would be made first.

To my mind it is not so much a question of inability of our chemists to produce dyes; for I believe that those trained in *practical* organic chemistry (not necessarily research chemists) would in a short time grasp the situation quickly, but it is a question of the *temporary handicap of not having the especially designed and constructed appliances* that are necessary for the proper conduct of the technical operations in elaborating the several raw materials to middle and ultimate products.

Here is the familiar example of benzopurpurine 4/B, one of the most common cotton dyes; starting with *toluol* and gradually converting this into *tolidine* means four chief processes made up of a succession of minor operations, thus: Toluene is nitrated, kept cool, and then distilled, the resulting nitrotoluene is reduced with zinc and caustic soda, yielding hydrazotoluene which is in turn broken up with muriatic acid, giving us the tolidine, which we combine with naphthionic acid, which is also the end product commencing with naphthalene, and converted in turn into nitronaphthalene, then naphthylamine, and finally naphthionic acid.

In the foregoing, no mention is made of the appliances that must be installed for the particular purpose of working the chemical reactions.

The problem is to provide for the chemical engineers' side of the factory work, and with a proper conservation of our own tars, it is not impossible that a wide range of colors might be produced here.

To found an industry is, however, quite a different matter from starting a factory, and for an industry to proceed orderly, requires that there must be at hand raw material and the constructive engineering ability to take care of the elaboration, and in this particular industry our American machinists and constructors have not been called upon to show what they can do.

The Iron and Steel Market

All the iron and steel producing countries of any consequence, with the sole exception of the United States, are engaged in the fiercest and most destructive war of all time. The countries at war are those that have been engaged in financing the development of non-productive but consuming countries, these countries having of late been taking from the producing countries upwards of 10,000,000 tons of finished steel a year, besides large quantities of machinery, hardware and cutlery, involving perhaps a couple million tons in addition. Of the total tonnage the United States has been furnishing about one-fourth.

A condition is presented the effects of which are impossible to gauge. There is no experience to guide, and the situation is so new that thus far it presents no trends that can be studied to advantage.

To add to the complexity, the iron producing countries at war are differently affected. Germany is hemmed in and cannot pursue her foreign commerce. England seems able shortly to resume her commerce, so far as ocean transport is concerned, but may be crippled in actual production through shortage of men, and perhaps also of certain raw materials.

The desire for commerce was at the root of this war, and it is natural and consistent that England should now endeavor to continue and even, if possible, expand her commerce. The United States is equally disposed to expand its commerce, but instead of being able at once to begin expanding, is confronted at the outset with a lack of ocean transportation facilities to continue the commerce already acquired, and is faced with the prospect that the so-called "neutral markets," through the withdrawal of European financial accommodations and a complete tying up of the mediums of international money exchange, are unable at the moment to buy.

At the first announcement of war the steel trade of the United States appeared to embrace the conclusion that an immediate and large demand would spring up for its products, but it required only a few days of observation and consideration to develop that the most serious difficulties lay in the way.

A problem serious in itself arose from the shutting off of imports of ferromanganese, manganese ore and Austrian magnesite. Ferromanganese, which had been readily available at $37 for German and $38 for English, f. o. b. Baltimore, jumped to $140 or $150 for odd lots to be shipped from surplus stocks, though a decline has since occurred to a trifle above $100, there being promise of an early resumption of shipments from England, though possibly on a restricted scale. Eventually there may be larger imports than formerly of manganese ore from Brazil and India. For magnesite a substitute, however expensive in the use, will doubtless have to be found.

The domestic trade of the United States has been affected in various ways. There has been some tendency on the part of buyers to take early deliveries from mills, on contracts made at recent minimum prices, through fear of a possible shortage later, while on the other hand there has developed a strong feeling of conservatism as to fresh purchases. New projects that require financing have been indefinitely held up.

What has occurred thus far since the war started is probably no index of what may follow. Early in August prices of bars, plates, shapes and sheets were advanced, largely as a precautionary measure on the part of the mills, faced by higher prices for ferromanganese and the possibility of a labor shortage, and additional advances are predicted. The wire advance of August 21 did not grow out of the war, but was a sequel to the advance of July 20, advances in wire products, on account of the peculiar manner in which the wire market is conducted, usually being made in multiple. Steel prices in general may advance further as the war progresses, but there is no clear indication thus far that such will be the case.

As to domestic demand, the total has not thus far been materially reduced, but as work in progress is completed there may be a decided slackening.

As to exports, the first war effect was to shut off the movement entirely, through there being no ocean movement and no means for payment. The first step is to restore exports to the former volume, the second being, if possible, to increase the volume, and that second step may not be reached for months. That the building up of an export trade will be slow is suggested by the fact that our exports to Canada have been decreased, instead of being increased by the fact that British exports to Canada were immediately, though presumably only temporarily, shut off. Indeed, the Canadian steel manufacturers themselves have decreased their production.

As to domestic trade, it is significant that while some fairly large railroad buying was expected to follow a decision in the eastern rate case, rendered August 1, the fact is that orders for only 2,000 freight cars were reported during August, when the monthly average during the first seven months of the year was about 10,000 cars.

The steel mills operated during August at about 65 per cent of capacity, or at about the same rate as in July, when the prospects had been that operations would

steadily increase. At the moment the prospect is that September output will be less rather than more than the August output.

Pig Iron

The pig iron market has been practically stagnant during August, and the seaboard markets, relieved of the fear of imports, have been unable to stiffen. Deliveries have shown practically no change, but it is uncertain whether they can be maintained indefinitely. Prices are largely nominal, and are quotable at little variation from those of a month ago: No. 2 foundry, f. o. b. Birmingham, $10 to $10.25; delivered Philadelphia, $14.25 to $14.50; f. o. b. furnace, Buffalo, $13 to $13.50; f. o. b. furnace, Chicago, $14; f. o. b. valley furnaces (90 cents higher delivered Pittsburgh) Bessemer, $14; basic, $13; No. 2 foundry and malleable, $13 to $13.25; gray forge, $12.50 to $12.75.

Steel

The mills have marked up quotations about $1 a ton since the war, the advance being based partly upon higher prospective costs, and it is asserted in some quarters that further advances will soon be made. Consumers are fairly well covered by old contracts. The market is quotable at $20.50 and $21.50 for billets and sheet bars respectively, f. o. b. maker's mill, Pittsburgh, and at $20 and $21 respectively at maker's mill, Youngstown, rods being about $26, Pittsburgh.

Finished Steel

Finished steel prices are firmly maintained, in most cases at advances from quotations of a month ago. Prices quoted below are for prompt shipment, fourth quarter shipment being as a rule $1 or $2 a ton higher. Quotations are f. o. b. Pittsburgh, unless otherwise stated, with full freight to point of delivery, and the Chicago and eastern markets are practically on this basis, concessions of part of the freight having practically disappeared.

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f. o. b. mill, except Colorado.

Plates, tank quality, 1.20c.

Shapes, 1.20c.

Steel bars and bands, 1.20c., base.

Iron bars, 1.25c., Pittsburgh; 1.17½ to 1.22½c., Philadelphia; 1.07½ to 1.10c., Chicago.

Sheets, blue annealed, 10 gage, 1.40c.; black, 28 gage, 1.90c.; galvanized, 28 gage, 2.90c.; painted corrugated, 28 gage, 2.10c.; galvanized corrugated, 28 gage, 2.95c.

Steel pipe, ¾ in. to 3 in., 80 per cent. off list.

Steel boiler tubes, 3½ to 4½ in., 72 per cent. off list.

Wire nails, $1.60, base; smooth fence wire, 1.40c.; galvanized fence wire, 1.80c.; galvanized barb wire, 2.00c.

Standard railroad spikes, 1.45 to 1.50c., Pittsburgh; 1.50 to 1.55c., Chicago.

Structural rivets, 1.55 to 1.60c.; boiler rivets, 1.65 to 1.70c.

Cold rolled shafting, 66 per cent. off list.

Chain, ⅜ in. proof coil, 3.05 to 3.15c.

The American Boiler Manufacturers' Association will hold its 26th annual convention in New York City from September 1 to 4, with headquarters at the Waldorf-Astoria Hotel. Mr. F. B. Slocum, West and Calyer Streets, Brooklyn, N. Y., is the secretary.

The Hardinge Conical Mill Co., of New York City, has received a fifth repeat order from the Braden Copper Company of Rancagua, Chile, for six Hardinge mills. These mills are all 8-ft. diameter by 48-in. cyl. and are to be driven by single-reduction herringbone gears of the Wuest type.

The Western Metallurgical Field

The Complex-Ore Problem

In the editorial summary of the symposium on complex ores, published in our July issue, an important point suggested by one or two of the contributors was not sufficiently emphasized. The economic loss of metals, particularly lead and zinc, due to imperfect methods of separation by ore-dressing methods is an item which, in the aggregate, must be tremendous. The smelter demands concentrates of a certain grade and purity in order that he may conduct his own operations to the best advantage. This places a limitation on the ore producer who, in meeting the demand for marketable concentrates, usually finds it necessary to sacrifice high recovery. Metallurgical saving is subordinated to economic recovery, and losses accrue proportionately. Lead remaining in zinc concentrate represents an economic loss, and the same is true of zinc in lead concentrate.

An illustration of these losses was given, referring to a published statement of a Montana producer of zinc concentrate. The recovery was high—90%—and the grade of concentrate was good—50% zinc; but it contained also small percentages of lead and copper, with some silver and gold. The gross value of the merchantable metals, based on current quotations, was about $80 per ton of concentrate. The actual market value at the smelter was about $24, leaving a difference of $56. A part of this difference is accounted for in freight, smelting and marketing charges, but much of it probably represents a loss to the producer due to economic conditions in the smelting industry. Such instances emphasize the limitations of present methods of concentration and increase the demand for new processes that are more efficient.

Dry Jigging Unsized Ore

One of the features of the Plumb pneumatic jig, described in this journal December, 1913, page 722, is its ability to produce concentrates of unusually high grade. In fact, according to the principle on which the jig operates, only high-grade, clean concentrates can be produced, and the saving is proportional to the degree in which the minerals have been unlocked in crushing. Some of the tests made by jigging the concentrates from wet tables showed the possibility of improving the grade to such an extent that their commercial value was greatly enhanced. In general, one of the advantages of the machine is that it overcomes in a large degree the economic loss referred to above in the concentration of lead-zinc ores, because the concentrates are not only of high grade, but the percentage recovery also is high.

At the time the jig was first described it was considered necessary to provide a feed that was sized within reasonably wide limits, say —12+20, —20+40 and —40+150 mesh. Ore finer than 150-mesh was not treated, as that size was considered outside the field of the machine. A recent development is that unsized feed can be treated as efficiently as sized feed, without eliminating the finest portion. This offers an advantage in avoiding the cost and trouble of sizing, as well as saving the mineral formerly discarded in the —150 mesh portion and treated on wet slime concentrators.

The development will sound illogical to those who have followed dry concentration, because sizing has been considered one of the prerequisites for successful work. But it is quite as logical as Joplin practice of wet-jigging unsized feed, where the fine mineral finds its way through the bed into the hutch, and the coarser grades accumulate on the bed and are discharged. It has been found that the same conditions obtain in a

Plumb pneumatic jig, working with a coarser screen than was formerly used. After a suitable bed has been formed coarse and fine mineral are recovered, the former at the usual discharge weir and the latter through the hutch. Apparently this is one of the cases where sizing can be dispensed with.

Telluride's Disaster

Engineers throughout the country will regret to learn of the disaster which befell the mining community

FIG. 1—PATH OF FLOOD FROM MOUTH OF CANON, LOOKING TOWARD BEAR CREEK

of Telluride on July 27, as the result of a cloudburst in the Sawtooth range, north of the town. The flood of water and mud which poured out of Cornet Creek canon, followed closely after a heavy rain, and covered about fifteen blocks in the central business and residential section with mud and debris to a depth of from four to ten feet. Detailed reports of the disaster tell of residences swept away by the flood, and others filled with mud and boulders. The New Sheridan Hotel, which has been the rendezvous of engineers visiting

FIG. 2—SLUICE CONSTRUCTION

Telluride, was one of the business blocks inundated. The Commercial Club was wrecked and filled with mud to within a few inches of the ceiling. The First National Bank building also was damaged.

Immediately following the storm, a committee headed by Mr. Charles A. Chase, manager for the Liberty Bell Gold Mining Co., laid plans for cleaning the town. A flume was constructed through the inundated section, and by the aid of the water from Cornet Creek and the local water system the accumulation of mud was sluiced to the San Miguel River. It will be several weeks before the tremendous volume of mud and debris can be removed.

The flood occurred about one o'clock in the afternoon, which possibly accounts for the fact that but one fatality resulted. The loss is estimated at about $200,000, sustained by residents and business houses. The local mining companies contributed liberally to a relief fund, but it is likely that offers of financial assistance from other sources outside Telluride will have to be accepted.

Purchase of Aurora Consolidated

The Goldfield Consolidated Mines Co. has issued an official statement regarding the terms of its purchase of the property of the Aurora Consolidated Mines Co., at Aurora, Mineral county, Nevada. The Goldfield company purchased 592,000 shares, equal to 87% of the issued shares of Aurora Consolidated, at a price of

FIG. 3—SLUICING—THE SIDE OF SLUICE REMOVED AND MUD FORCED IN BY FIRE HOSE

$1.28887 per share, or on the basis of $877,075 for the entire issue. Cash paid on June 25, the date of purchase, was $388,800; three subsequent payments of $100,000 each, with interest at 6% per annum were arranged for at thirty-day intervals, and the final payment of $74,211 is tot be made on October 25. At the time of the purchase, mining and milling equipment with an estimated capacity of 500 tons per day was practically completed and ready for operation. The estimated net value of fully and partly developed ore, after deducting estimated cost of realization, was $893,000. The developed ore has a gross value of $4.81 per ton, from which it is expected to realize a net profit of $1.50 per ton by cyanidation. Owing to the disbursement of a large sum in this purchase, the Goldfield company has omitted its usual dividend payment.

Calumet & Hecla to Leach Tailings

Although no details are available at the present time, it is understood that the Calumet & Hecla Mining Co., Michigan, is planning to leach the tailings from its new regrinding and reconcentrating plant. Tailings from early concentration are to be dredged from Lake Linden, reground in Hardinge mills and reconcentrated. The tailings will then be classified in Dorr classifiers of special design, and the sand product subjected to a leaching process to recover the contained copper.

Some Aspects of Industrial Chemistry*

BY DR. L. H. BAEKELAND

While I appreciate deeply the distinction of speaking before you on the occasion of the fiftieth anniversary of the Columbia School of Mines, I realize, at the same time, that nobody here present could do better justice to the subject which has been chosen for this lecture than the beloved master in whose honor the Charles Frederick Chandler Lectureship has been created.

Dr. Chandler, in his long and eminently useful career as a professor and as a public servant, has assisted at the very beginning of some of the most interesting chapters of applied chemistry, here and abroad.

Some of his pupils have become leaders in chemical industry; others have found in his teachings the very conception of new chemical processes which made their names known throughout the whole world.

Industrial chemistry has been defined as "the chemistry of dollars and cents."

This rather cynical definition, in its narrower interpretation, seems to ignore entirely the far-reaching economic and civilizing influences which have been brought to life through the applications of science; it fails to do justice to the fact that the whole fabric of modern civilization becomes each day more and ever more interwoven with the endless ramifications of applied chemistry.

Beginning of Chemical Industries in France

The earlier effects of this influence do not date back much beyond one hundred and odd years. They became distinctly evident during the first French Republic, increased under Napoleon, gradually spread to neighboring countries, and then reaching out farther, their influence is now obvious throughout the whole world.

France, during the revolution, scattered to the winds old traditions and conventionalities, in culture as well as in politics. Until then, she had mainly impressed the world by the barbaric, wasteful splendor of her opulent kings, at whose courts the devotees of science received scant attention in comparison to the more ornamental artists and belles-lettrists, who were petted and rewarded alongside of the all-important men of the sword.

In fact, as far as the culture of science was concerned, the Netherlands, Germany and Italy, and more particularly England, were head and shoulders above the France of "le Roi Soleil."

The struggles of the new régime put France in the awkward position of the legendary beaver which "had to climb a tree."

If for no other reason, she needed scientists to help her in her wars against the rulers of other European nations. She needed them just as much for repairing her crippled finances and her badly disturbed industries which were dependent upon natural products imported until then, but of which the supply had suddenly been cut off by the so-called Continental Blockade. Money-prizes and other inducements had been offered for stimulating the development of chemical processes, and —what is more significant—patent laws were promulgated so as to foster invention.

Nicolas Leblanc's method for the manufacture of soda to replace the imported alkalis, Berthollet's method for bleaching with chlorine, the beet-sugar industry, to replace cane sugar imported from the colonies, and several other processes, were proposed.

All these chemical processes found themselves soon lifted from the hands of the secretive alchemist or the timid pharmacist to the rank of real manufacturing methods. Industrial chemistry had begun its lusty career.

First successes stimulated new endeavors and small wonder is it that France, with these favorable conditions at hand, for a while at least, entered into the most glorious period of that part of her history which relates to the development of chemistry, and the arts dependent thereon.

It is difficult to imagine that, at that time, Germany, which now occupies such an enviable position in chemistry, was so far behind that even in 1822, when Liebig wanted to study chemistry at the best schools, he had to leave his own country, and turn to Gay-Lussac, Thénard and Dulong in Paris.

Development of British Chemical Industry

But the British were not slow to avail themselves of the new opportunities in chemical manufacturing so clearly indicated by the first successes of the French. Their linen bleacheries in Scotland and England soon used an improved method for bleaching with chloride of lime, developed by Tennant, which brought along the manufacture of other chemicals relating thereto, like sulphuric acid and soda.

The chemical reactions involved in all these processes are relatively simple, and after they were once well understood it required mainly resourceful engineering and good commercial abilities to build up successfully the industries based thereon.

From this epoch on dates the beginning of the development of that important industry of heavy chemicals in which the British led the world for almost a century.

In the same way, England had become the leader in another important branch of chemical industry—the manufacture of coal-gas.

Development of German Chemical Industries

The Germans were soon to make up for lost time. Those same German universities which, when Liebig was a young man, were so poorly equipped for the study of chemistry, were now enthusiastically at work on research along the newer developments of the physical sciences, and before long, the former pupils of France, in their turn, became teachers of the world.

Liebig had inaugurated for the chemical students working under him his system of research laboratories; however modest these laboratories may have been at that time, they carried bodily the study of chemistry from pedagogic boresomeness into a captivating cross-examination of nature.

And it seemed as if nature had been waiting impatiently to impart some of her secrets to the children of men, who for so many generations had tried to settle truth and knowledge by words and oratory and by brilliant displays of metaphysical controversies.

Indeed, at that time, a few kitchen tables, some clumsy glassware, a charcoal furnace or two, some pots and pans, and a modest balance were all that was needed to make nature give her answers.

These modest paraphernalia, eloquent by their very simplicity, brought forth rapidly succeeding discoveries. One of them was truly sensational: Liebig and Wöhler succeeded in accomplishing the direct synthesis of urea; thinking men began to realize the far-reaching import of this revolutionary discovery whereby a purely organic substance had been created in the laboratory by starting exclusively from inorganic materials. This result upset all respected doctrines that organic substances are of a special enigmatic constitution, altogether different from inorganic or mineral compounds, and that they only could be built up by the agency of

*An address given at Columbia University to inaugurate the Charles F. Chandler Lectureship. Copyrighted by the Columbia University Press, 1914.

the so-called "vital force"—whatever that might mean.

Research in organic chemistry became more and more fascinating; all available organic substances were being investigated one after another by restless experimentalists.

Coal tar, heretofore, a troublesome by-product of gas manufacture, notwithstanding its uninviting, ill-smelling, black sticky appearance, did not escape the general inquisitive tendency; some of its constituents, like benzol or others, were isolated and studied.

Under the brilliant leadership of Kékulé, a successful attempt was made to correlate the rapidly increasing new experimental observations in organic chemistry into a new theory which would try to explain all the numerous facts; a theory which became the sign-post to the roads of further achievements.

Stimulating Influences of the Dye Industry on Organic Chemistry

The discovery of quickly succeeding processes for making from coal-tar derivatives numerous artificial dyes, rivaling, if not surpassing, the most brilliant colors of nature, made the group of bold investigators still bolder. Research in organic chemistry began to find rapid rewards; entirely new and successful industries based on purely scientific data were springing up in England and France, as well as in Germany.

Some wide-awake leaders of these new enterprises, more particularly in Germany, soon learned that they were never hampered by too much knowledge, but that, on the contrary, they were almost continuously handicapped in their impatient onward march by insufficient knowledge, or by misleading conceptions, if not by incorrect published facts.

This is precisely where the study of organic chemistry received its greaetest stimulating influence and soon put Germany in this branch of science, ahead of all other nations.

Money and effort had to be spent freely for further research. The best scholars in chemistry were called into action. Some men, who were preparing themselves to become professors, were induced to take a leading part as directors in one or another of the new chemical enterprises. Others, who refused to forsake their teachers' career, were retained as advisers or guides, and, in several instances, the honor of being the discoverers of new processes, or a new dye, was made more substantial by financial rewards. The modest German university professor, who heretofore had lived within a rather narrow academic sphere, went through a process of evolution, where the rapidly growing chemical industry made him realize his latent powers and greater importance, and broadened his influence way beyond the confines of his lecture-room. Even if he were altruistic enough to remain indifferent to fame or money, he felt stimulated by the very thought that he was helping, in a direct manner, to build up the nation and the world through the immediate application of the principles of science.

Industrial Research Laboratories

In the beginning, science did all the giving and chemical industry got most of the rewards; but soon the rôles began to change to the point where frequently they became entirely inverted. The universities did not furnish knowledge fast enough to keep pace with the requirements of the rapidly developing industries. Modern research laboratories were organized by some large chemical factories on a scale never conceived before, with a lavishness which made the best equipped university laboratory appear like a timid attempt. Germany, so long behind France and England, had become the recognized leader in organic manufacturing processes, and developed a new industrial chemistry based more on the thorough knowledge of organic chemistry than on engineering skill.

In this relation, it is worth while to point out that the early organic industrial chemistry, through which Germany was soon to become so important, at first counted its output not in tons, but in pounds—not in size nor in quantity, but in variety and quality.

Now let us see how Germany won her spurs in chemical engineering as well:

At the beginning, the manufacturing problems in organic chemistry involved few, if any, serious engineering difficulties, but required, most of all, a sound theoretical knowledge of the subject; this put a premium on the scientist, and could afford, for a while at least, to ignore the engineer. But when growing developments began to claim the help of good engineers, there was no difficulty whatsoever in supplying them, nor in making them cooperate with the scientists. In fact, since then, Germany has solved, just as successfully, some of the most extraordinary chemical engineering problems ever undertaken, although the development of such processes was entered upon at first from the purely scientific side.

In almost every case, it was only after the underlying scientific facts had been well established, that any attempt was made to develop them commercially.

Methods of Healthy Development of Scientific Processes

Healthy commercial development of new scientific processes does not build its hope of success upon the cooperation of that class of "promoters" which are always eager to find any available pretext for making "quick money," and whose scientific ignorance contributes conveniently to their comfort by not interfering too much with their self-assurance and their voluble assertions. The history of most of the successful recent chemical processes abounds in examples where, even after the underlying principles were well established, long and costly preparatory team-work had to be undertaken; where foremost scientists, as well as engineers of great ability, had to combine their knowledge, their skill, their perseverence, with the support of large chemical companies, who, in their turn, could rely on the financial backing of strong banking concerns, well advised by tried expert specialists.

History does not record how many processes thus submitted to careful study were rejected because, on close examination, they were found to possess some hopeless shortcomings. In this way, numerous fruitless efforts and financial losses were averted, where less carefully accumulated knowledge might have induced less scrupulous promoters to secure money for plausible but ill-advised enterprises.

In the history of the manufacture of artificial dyes, no chapter gives a more striking instance of long, assiduous and expensive preliminary work of the highest order than the development of the industrial synthesis of indigo. Here was a substance of enormous consumption which, until then, had been obtained from the tropics as a natural product of agriculture.

Professor von Baeyer and his pupils, by long and marvelously clever laboratory work, had succeeded by-and-by in unraveling the chemical constitution of this indigo dye, and had finally indicated some possible methods of synthesis. Notwithstanding all this, it took the Badische Aniline & Soda Fabrik about twenty years of patient research work, carried out by a group of eminent chemists and engineers, before a satisfactory method was devised by which the artificial product

could compete in price and in quality with natural indigo.

Germany, with her well-administered and easily enforcible patent laws, has added, through this very agency, a most vital inducement for pioneer work in chemical industries. Who otherwise would dare to take the risk of all the expenses connected with this class of creative work? Moreover, who would be induced to publish the result of his discoveries far and wide throughout the whole world in that steadily flowing stream of patent literature, which, much sooner than any text-books or periodicals, enables one worker to be benefited and to be inspired by the publication of the latest work of others?

International Scope of Chemical Research

The development of some problems of industrial chemistry has enlisted the brilliant collaboration of men of so many different nationalities that the final success could not, with any measure of justice, be ascribed exclusively to one single race or nation; this is best illustrated by the invention of the different methods for the fixation of nitrogen from the air.

This extraordinary achievement, although scarcely a few years old, seems already an ordinary link in the chain of common, current events of our busy life; and yet, the facts connected with this recent conquest reveal a modern tale of great deeds of the race—an epos of applied science.

Its story began the day when chemistry taught us how indispensable are the nitrogeneous substances for the growth of all living beings.

Nitrogen Fertilizers

Generally speaking, the most expensive food-stuffs are precisely those which contain most nitrogen; for the simple reason that there is, and always has been, at some time or another, a shortage of nitrogeneous foods in the world. Agriculture furnishes us these proteid- or nitrogen-containing bodies, whether we eat them directly as vegatable products, or indirectly as animals which have assimilated the proteids from plants.

It so happens, however, that, by our ill-balanced methods of agriculture, we take nitrogen from the soil much faster than it is supplied to the soil through natural agencies. We have tried to remedy this discrepancy by enriching the soil with manure or other fertilizers, but this has been found totally insufficient, especially with our methods of intensive culture—our fields want more nitrogen.

So agriculture has been looking anxiously around to find new sources of nitrogen fertilizer. For a short time, an excellent supply was found in the guano deposits of Peru; but this material was used up so eagerly that the supply lasted only a very few years. In the meantime, the ammonium salts recovered from the by-products of the gas-works have come into steady use as nitrogen fertilizer. But, here again, the supply is entirely insufficient, and during the later period our main reliance has been placed on the natural beds of sodium nitrate, which are found in the desert regions of Chile. This has been, of late, our principal source of nitrogen for agriculture, as well as for the many industries which require saltpeter or nitric acid.

In 1898, Sir William Crookes, in his memorable presidential address before the British Association for the Advancement of Science, called our attention to the threatening fact that, at the increasing rate of consumption, the nitrate beds of Chile would be exhausted before the middle of this century. Here was a warning—an alarm call—raised to the human race by one of the deepest scientific thinkers of our generation. It meant no more nor less than that before long our race would be confronted with nitrogen starvation.

In a given country, all other conditions being equal, the abundance or the lack of nitrogen available for nutrition is a paramount factor in the degree of general welfare, or of physical decadence. The less nitrogen there is available as food-stuffs, the nearer the population is to starvation. The great famines in such nitrogen-deficient countries as India and China and Russia are sad examples of nitrogen starvation.

And yet, nitrogen, as such, is so abundant in nature that it constitutes four-fifths of the air we breathe. Every square mile of our atmosphere contains nitrogen enough to satisfy our total present consumption for over half a century. However, this nitrogen is unavailable as long as we do not find means to make it enter into some suitable chemical combination. Moreover, nitrogen was generally considered inactive, and inert, because it does not enter readily in chemical combination.

William Crookes' disquieting message of rapidly approaching nitrogen starvation did not cause much worry to politicians—they seldom look so far ahead into the future. But, to the men of science, it rang like a reproach to the human race. Here, then, we were in possession of an inexhaustible store of nitrogen in the air, and yet, unless we found some practical means for tying some of it into a suitable chemical combination, we should soon be in a position similar to that of a shipwrecked sailor, drifting around on an immense ocean of brine, and yet slowly dying for lack of drinking water.

Nitric Acid from Air by Means of Electric Discharges

As a guiding beacon, there was, however, that simple experiment, carried out in a little glass tube, as far back as 1785, by both Cavendish and Priestly, which showed that if electric sparks were passed through air, the oxygen thereof was able to burn some of the nitrogen and to engender nitrous vapors.

This seemingly unimportant laboratory curiosity, so long dormant in the text-books, was made a starting point by Charles S. Bradley and D. R. Lovejoy, in Niagara Falls, for creating the first industrial apparatus for converting the nitrogen of the air into nitric acid by means of the electric arc.

As early as 1902, they published their results as well as the details of their apparatus. Although they operated only one full-sized unit, they demonstrated conclusively that nitric acid could thus be produced from the air in unlimited quantities. We shall examine later the reasons why this pioneer enterprise did not prove a commercial success; but to these two American inventors belongs, undoubtedly, the credit of having furnished the first answer to the distress call of Sir William Crookes.

In the meantime many other investigators were at work at the same problem, and soon from Norway's abundant water-falls came the news that Birkeland and Eyde had solved successfully, and on a commercial scale, the same problem by a differently constructed apparatus. The Germans, too, were working on the same subject, and we heard that Schoenherr, also Pauling, had evolved still other methods, all, however, based on the Cavendish-Priestly principle of oxidation of nitrogen. In Norway alone the artificial saltpeter factories use now, day and night, over 200,000 electrical horse-power, which will soon be doubled; while a further addition is contemplated which will bring the volume of electric current consumed to about 500,000 horse-power. The capital invested at present in these works amounts to $27,000,000.

Cyanamide

Frank and Caro, in Germany, succeeded in creating another profitable industrial process whereby nitrogen could be fixed by carbide of calcium, which converts it into calcium cyanamide, an excellent fertilizer by itself. By the action of steam on cyanamide, ammonia is produced, or it can be made the starting point of the manufacture of cyanides, so profusely used for the treatment of gold and silver ores.

Although the synthetic nitrates have found a field of their own, their utilization for fertilizers is smaller than that of the cyanamide; and the latter industry represents to-day, an investment of about $30,000,000, with three factories in Germany, two in Norway, two in Sweden, one in France, one in Switzerland, two in Italy, one in Austria, one in Japan, one in Canada, but not any in the United States. The total output of cyanamide is valued at $15,000,000 yearly and employs 200,000 horse-power, and preparations are made at almost every existing plant for further extensions. An English company is contemplating the application of 1,000,000 horse-power to the production of cyanamide and its derivatives, 600,000 of which have been secured in Norway and 400,000 in Iceland.

Nitride Processes

But still other processes are being developed, based on the fact that certain metals or metalloids can absorb nitrogen, and can thus be converted into nitrides; the latter can either be used directly as fertilizers or they can be made to produce ammonia under suitable treatment.

The most important of these nitrade processes seems to be that of Serpek, who, in his experimental factory at Niedermorschweiler, succeeded in obtaining aluminum nitrade in almost theoretical quantities, with the use of an amount of electrical energy eight times less than that needed for the Birkeland-Eyde process and one half less than for the cyanamide process, the results being calculated for equal weights of "fixed" nitrogen.

A French company has taken up the commercial application of this process which can furnish, besides ammonia, pure alumina for the manufacture of aluminum metal.

Haber's Ammonia Process

An exceptionally ingenious process for the direct synthesis of ammonia, by the direct union of hydrogen with nitrogen, has been developed by Haber in conjunction with the chemists and engineers of the Badische Aniline & Soda Fabrik.

The process has the advantage that it is not, like the other nitrogen-fixation processes, paramountly dependent upon cheap power; for this reason, if for no other, it seems to be destined to a more ready application. The fact that the group of the three German chemical companies which control the process have sold out their former holdings in the Norwegian enterprises to a Norwegian-French group, and are now devoting their energies to the commercial installation of the Haber process, has quite some significance as to expectation for the future.

The Future of Nitrogen-Fixation Processes

The question naturally arises: Will there be an over-production and will these different rival processes not kill each other in slaughtering prices beyond remunerative production?

As to over-production, we should bear in mind that nitrogen fertilizers are already used at the rate of about $200,000,000 worth a year, and that any decrease in price, and, more particularly, better education in farming, will probably lead to an enormously increased consumption. It is worth mentioning here that in 1825, the first shipload of Chile saltpeter, which was sent to Europe, could find no buyer, and was finally thrown into the sea as useless material.

Then again, processes for nitric acid and processes for ammonia, instead of interfering, are supplementary to each other, because the world needs ammonia and ammonium salts, as well as nitric acid or nitrates.

It should be pointed out, also, that ultimately, the production of ammonium nitrate may prove the most desirable method so as to minimize freight; for this salt contains much more nitrogen to the ton than is the case with the more bulky calcium-salt, under which form synthetic nitrates are now put into the market.

Before leaving this subject, let us examine why Bradley and Lovejoy's efforts came to a standstill where others succeeded.

First of all, the cost of power at Niagara Falls is three to five times higher than in Norway, and although at the time this was not strictly prohibitive for the manufacture of nitric acid, it was entirely beyond hope for the production of fertilizers. The relatively high cost of power in our country is the reason why the cyanamide enterprise had to locate on the Canadian side of Niagara Falls, and why, up till now, outside of an experimental plant in the South (a 4,000 horse-power installation in North Carolina, using the Pauling process), the whole United States has not a single synthetic nitrogen fertilizer works.

The yields of the Bradley-Lovejoy apparatus were rather good. They succeeded in converting as much as two and one-half per cent of the air, which is somewhat better than their successors are able to accomplish.

But their units, 12 kilowatts, were very much smaller than the 1,000 to 3,000 kilowatts now used in Norway; they were also more delicate to handle, all of which made installation and operation considerably more expensive.

However this was the natural phase through which any pioneer industrial development has to go, and it is more than probable that in the natural order of events, these imperfections would have been eliminated.

But the killing stroke came when financial support was suddenly withdrawn.

Necessity of Scientific Team-Work and Good Financial Backing

In the successful solution of similar industrial problems, the originators in Europe were not only backed by scientifically well-advised bankers, but they were helped to the rapid solution of all the side problems by a group of specially selected scientific collaborators, as well as by all the resourcefulness of well-established chemical enterprises.

That such conditions are possible in the United States has been demonstrated by the splendid team-work which led to the development of the modern tungsten lamp in the research laboratories of the General Electric Company, and to the development of the Tesla polyphase motor, by the group of engineers of the Westinghouse Company.

True, there are endless subjects of research and development which can be brought to success by the efforts of single independent inventors, but there are some problems of applied science which are so vast, so much surrounded with ramifying difficulties, that no one man, or two men, however exceptional, can either furnish the brains or the money necessary for leading to success within a reasonable time. For such special problems, the rapid cooperation of numerous experts and the financial resources of large establishments are indispensable.

All these examples of the struggle for efficiency and improvement demonstrate why, in industrial chemistry, the question of *dollars and cents* has to be taken very much into consideration.

From this standpoint at least, the "dollars and cents" argument can be interpreted as a symptom of industrial efficiency, and thus, the definition sounds no longer as a reproach. With some allowable degree of accuracy, it formulates one of the economic aspects of any acceptable industrial chemical process.

Indeed, barring special conditions, as, for instance, incompetent or reckless management, unfair competition, monopolies, or other artificial privileges, the money success of a chemical process is the cash plebiscite of approval of the consumers. It is bound, after a time at least, to weed out the inefficient methods.

Influence of Secondary Factors in Chemical Processes

Some chemists, who have little or no experience with industrial enterprises, are too much over-inclined to judge a chemical process exclusively from the standpoint of the chemical reactions involved therein, without sufficient regard to engineering difficulties, financial requirements, labor problems, market and trade conditions, rapid development of the art involving frequent disturbing improvements in methods and expensive changes in equipment, advantages or disadvantages of the location of the plant, and other conditions so numerous and variable that many of them can hardly be foreseen even by men of experience.

And yet, these seemingly secondary considerations most of the time become the deciding factor of success or failure of an otherwise well-conceived chemical process.

The cost of transportation alone will, frequently, decide whether a certain chemical process is economically possible or not. For instance, the big Washoe Smelter, in Montana, wastes enough sulphuric-dioxide gas to make daily 1,800 tons of sulphuric acid, but that smelter is too far distant from any possible market for such a quantity of otherwise valuable material.

Natural Deposits of Soda

Another example of the kind is found in the natural deposits of soda or soda lakes in California. One of these soda lakes contains from thirty to forty-two million tons of soda. Here is a natural source of supply which would be ample to satisfy the world's demand for many years to come. Similar deposits exist in other parts of the world, but the cost of transportation to a sufficiently large and profitable market is so exorbitant that, in the meantime, it is cheaper to erect at more convenient points expensive chemical works in which soda is made chemically and from where the market can be supplied more profitably.

In addition, we can cite the artificial nitrate processes in Norway, which, notwithstanding their low efficiency and expensive installation, can furnish nitrate in competition with the natural nitrate beds of Chile, because the latter are hampered by the cost of extraction from the soil where fuel for crystallization is expensive, in addition to the considerable cost of freight.

Leblanc Soda

But there is no better example illustrating the far-reaching effect of seemingly secondary conditions upon the success of a chemical process than the history of the Leblanc soda process.

This famous process was the forerunner of chemical industry. For almost a century it dominated the enormous group of industries of heavy chemicals, so expressively called by the French "La Grande Industrie Chimique," and now we are witnesses of the lingering death agonies of this chemical colossus. Through the Leblanc process, large fortunes have been made and lost; but even after its death, it will leave a treasure of information to science and chemical engineering, the value of which can hardly be overestimated.

Here, then, is a very well worked-out process admirably studied in all its details,which, in its heroic struggle for existence, has drawn upon every conceivable resources of ingenuity furnished by the most learned chemists and the most skilful engineers, who succeeded in bringing it to an extraordinary degree of perfection, and which, nevertheless, has to succumb before inexorable, although seemingly secondary, conditions.

Solvay Process

Strange to say, its competitor, the Solvay process, entered into the arena after a succession of failures. When Solvay, as a young man, took up this process, he was, himself, totally ignorant of the fact that no less than about a dozen able chemists had invented and reinvented the very reaction on whicht he had pinned his faith; that, furthermore, some had tried it on a commercial scale, and had, in every instance, encountered failure. At that time, all this must, unodubtedly, have been to young Solvay a revelation sufficient to dishearten almost anybody. But he had one predominant thought to which he clung as a last hope of success, and which would probably have escaped most chemists; he reasoned that, in this process, he starts from two watery solutions, which, when brought together, precipitate a dry product, bicarbonate of soda; in the Leblanc process, the raw materials must be melted together with the use of expensive fuel, after which the mass is dissolved in water, losing all these valuable heat units, while more heat has again to be applied to evaporate to dryness.

After all, most of the weakness of the Leblanc process resides in the greater consumption of fuel. But the cost of fuel, here again, is determined by freight rates. This is so true that we find that the last few Leblanc works which manage to keep alive are exactly those which are situated near unusually favorable shipping points, where they can obtain cheap fuel, as well as cheap raw materials, and whence they can most advantageously reach certain profitable markets.

But another tremendous handicap of the Leblanc process is that it gives as one of its by-products, hydrochloric acid. Profitable use for this acid, as such, can be found only to a limited extent. It is true that hydrochloric acid could be used in much larger quantities for many purposes where sulphuric acid is used now, but it has, against sulphuric acid, a great freight disadvantage. In its commercially available condition, it is an aqueous solution, containing only about one third of real acid, so that the transportation of one ton of acid practically involves the extra cost of freight of about two tons of water. Furthermore, the transportation of hydrochloric acid in anything but glass carboys involves very difficult problems in itself, so that the market for hydrochloric acid remains always within a relatively small zone from its point of production. However, for a while at least, an outlet for this hydrochloric acid was found by converting it into a dry material which can easily be transported; namely, chloride of lime or bleaching-powder.

Electrolytic Processes a New Competitor

The amount of bleaching-powder consumed in the world practically dictated the limited extent to which the Leblanc process could be profitably worked in competition with the Solvay process. But even this outlet has been blocked during these later years by the advent of the electrolytic alkali processes, which have sprung

up successfully in several countries, and which give as a cheap by-product, chlorine, which is directly converted into chloride of lime.

To-day, any process which involves the production of large quantites of hydrochloric acid, beyond what the market can absorb as such, or as derivatives thereof, becomes a positive detriment, and foretells failure of the process. Even if we could afford to lose all the acid, the disposal of large quantities thereof conflicts immediately with laws and ordinances relative to the pollution of the atmosphere or streams, or the rights of neighbors, and occasions expensive damage suits.

Whatever is said about hydrochloric acid applies to some extent to chlorine, produced in the electrolytic manufacture of caustic soda. Here again, the development of the latter industry is limited, primarily, by the amount of chlorine which the market, as such, or as chlorinated products, can absorb.

At any rate, chlorine can be produced so much cheaper by electrolytic caustic alkali processes than formerly, and in the meantime the market price of chloride of lime has already been cut about in half.

In as far as the rather young electrolytic alkali industry has taken a considerable development in the United States, let us examine it somewhat nearer.

At present, the world's production of chloride of lime approximates about half a million tons.

We used to import all our chloride of lime from Europe, until about fifteen years ago, when the first successful electrolytic alkali works were started at Niagara Falls. That ingenious mercury cell of Hamilton Y. Castner—a pupil of Professor Chandler and one of the illustrious sons of the Columbia School of Mines—was first used, and his process still furnishes a large part of all the electrolytic caustic soda and chlorine manufactured here and abroad.

At present, about 30,000 electrical horse-power are employed uninterruptedly for the different processes used in the United States, and our home production has increased to the point where, instead of importing chloride of lime, we shall soon be compelled to export our surplus production.

It looks now as if, for the moment at least, any sudden considerable increase in the production of chloride of lime would lead to over-production until new channels of consumption of chloride of lime or other chlorine products can be found.

However, new uses for chlorine are being found every day. The very fact that commercial hydrochloric acid of exceptional purity is now being manufactured in Niagara Falls by starting from chlorine, indicates clearly that conditions are being reversed; no longer than a few years ago, when chlorine was manufactured exclusively by means of hydrochloric acid, this would have sounded like a paradox.

Organic Chlorine Products

The consumption of chlorine for the preparation of organic chlorination products utilized in the dye-stuff industry, is also increasing continually, and its use for the manufacture of tetrachloride of carbon and so-called acetylen chlorination products, has reached importance.

There is probably a much overlooked but wider opening for chlorinated solvents in the fact that ethylen-gas can be prepared now at considerably lower cost than acetylen, and that ethylen-chloride, or the old known "Dutch Liquid," is an unusually good solvent. It has, furthermore, the great advantage that its specific gravity is not too high, and its boiling point, too, is about the right temperature. It ought to be possible to make it at such a low price that it would find endless applications where the use of other chlorination solvents has thus far been impossible.

The chlorination of ores for certain metallurgical processes may eventually open a still larger field of consumption for chlorine.

In the meantime, liquified chlorine gas, obtained by great compression, or by intense refrigeration, has become an important article of commerce, which can be transported in strong steel cylinders. Its main utilization resides in the manufacture of tin chloride by the Goldschmidt process for reclaiming tin-scrap. It is finding, also, increased applications as a bleaching agent and for the purification of drinking water, as well as for the manufacture of various chlorination products.

Its great handicap for rapid introduction is again the question of freight, where heavy and expensive containers become indispensable.

In most cases the transportation problem of chlorine is solved more economically by handling it as chloride of lime, which, after all, represents chlorine or oxygen in solid form, easily transportable.

It would seem as if the freight difficulty could easily be eliminated by producing the chlorine right at the spot of consumption. But this is not always so simple as it may appear. To begin with, the cost of an efficient plant for any electrolytic operation is always unusually high as compared to other chemical equipments. Then, also, small electrolytic alkali plants are not profitable to operate. Furthermore, the conditions for producing cheap chlorine depend on many different factors, which all have to coordinate advantageously; for instance, cheap power, cheap fuel and cheap raw materials are essential, while, at the same time, a profitable outlet must be found for the caustic soda.

Lately, there has been a considerable reduction of the market price of caustic soda; all this may have for effect that the less efficient electrolytic processes will gradually be eliminated; although this may not necessarily be the case for smaller plants which do not compete in the open market, but consume their own output for some special purpose.

Advantages and Disadvantages of Different Types of Electrolytic Alkali Cells

Several distinct types of electrolytic cells are now in successful use, but experience seems to demonstrate that the so-called diaphragm cells are cheapest to construct and to operate, provided, however, no exception be taken to the fact that the caustic soda obtained from diaphragm cells always contains some sodium chloride, usually varying from two or three per cent, which it is not practical to eliminate, but which for almost all purposes does not interfere in the least with its commercial use.

Mercury cells give a much purer caustic soda, and this may, in some cases, compensate for their more expensive equipment and operation. Moreover, there are some purposes where the initial caustic solution of rather high concentration, produced directly in these cells, can be used as it is without further treatment, thus obviating further concentration and cost of fuel.

The expenses for evaporation and elimination of salt from the raw caustic solutions increase to an exaggerated extent with some types of diaphragm cells, which produce only very weak caustic liquors. This is also the case with the so-called "gravity cell," sometimes called the "bell type," or "Aussig type," of cell. But these gravity cells have the merit of dispensing with the delicate and expensive problem of diaphragms. On the other hand, their units are very small, and, on this account, they necessitate a rather complicated installation, occupying an unusually large floor space and expensive buildings.

The general tendency is now toward cells which can be used in very large units, which can be housed eco-

nomically, and of which the general cost of maintenance and renewal is small; some of the modern types of diaphragm cells are now successfully operating with 3000 to 5000 amperes per cell.

As to the possible future improvements in electrolytic alkali cells, we should mention that in some types the current efficiencies have practically reached their maximum and average ampere efficiencies as high as 95 to 97 per cent have been obtained in continuous practise. The main difficulty is to reinforce these favorable results by the use of lower voltage, without making the units unnecessarily bulky, or expensive in construction, or in maintenance, all factors which soon outweigh any intended saving of electric current.

Here, more than in any other branch of chemical engineering, it is easy enough to determine how "good" a cell is on a limited trial, but it takes expensive, long continuous use on a full commercial scale, running uninterruptedly day and night for years, to find out how "bad" it is for real commercial practise.

Cheap Power Not the Only Factor

In relation to the electrolytic alkali industry, a great mistake is frequently committed by considering the question of power as paramount; true enough, cheap power is very important, almost essential, but certainly it is not everything. There have been cases where it was found much cheaper in the end to pay almost double for electric current in a certain locality, than in another site not far distant from the first, for the simple reason that the cheaper power supply was hampered by frequent interruptions and expensive disturbances, which more than offset any possible saving in cost of power.

In further corroboration, it is well known that some of the most successful electrolytic soda manufacturers have found it to their advantage to sacrifice power by running their cells at decidedly higher voltage than is strictly necessary—which simply means consuming more power—and this in order to be able to use higher current densities, thereby increasing considerably the output of the same size units, and thus economizing on the general cost of plant operation. Here is one of the ever recurring instances in chemical manufacturing where it becomes more advantageous to sacrifice apparent theoretical efficiency in favor of industrial expediency.

All this does not diminish the fact that the larger electrochemical industries can only thrive where cheap power is available.

Importance of Cheap Power for Electrochemical Processes

Modern progress of electrical engineering has given us the means to utilize socalled natural powers; until now, however, we have only availed ourselves of the water-power developed from rivers, lakes and waterfalls. As far as large electric power generation is concerned, the use of the wind, or the tide, or the heat of the sun, represents, up till now, nothing much beyond a mere hope of future possibilities.

In the meantime, it so happens, unfortunately, that many of the most abundant water-powers of the world are situated in places of difficult access, far removed from the zone of possible utilization.

But, precisely on this account, it would appear, at first sight, as if the United States, with some of her big water-powers situated nearer to active centers of consumption, would be in an exceptionally favorable condition for the development of electrochemical industries. On closer examination, we find, however, that the cost of water-power, as sold to manufacturers, is, in general, much higher than might be expected; at any rate, it is considerably more expensive than the cost of electric power utilized in the Norway nitrate enterprises.

This is principally due to the fact that in the United States, water-power, before it is utilized by the electrolytic manufacturer, has already to pay one, two and sometimes three, profits, to as many intermediate interests, which act as so many middlemen between the original water-power and the consumer. Only in such instances as in Norway, where the electrochemical enterprise and the development of the water-power are practically in the same hands, can electric current be calculated at its real cheapest cost.

Neither should the fact be overlooked that the best of our water-powers in the east are situated rather far inland. Although this does not matter much for the home market, it puts us at a decided disadvantage for the exportation of manufactured goods, in comparison again with Norway, where the electrolytic plants are situated quite close to a good sea-harbor open in all seasons.

Increasing Use of Gas Power

Some electrochemical enterprises require cheap fuel just as much as cheap power; and, on this account, it has proved sometimes more advantageous to dispense entirely with water-power by generating gas for fuel as well as for power from cheap coal or still cheaper peat.

At present most of our ways of using coal are still cumbersome and wasteful, although several efficient methods have been developed which some day will probably be used almost exclusively, principally in such places where lower grades of cheap coal are obtainable.

I refer here particularly to the valuable pioneer work of that great industrial chemist, Mond, on cheap water-gas production, by the use of limited amount of air in conjunction with water vapor.

More recently this process has been extended by Caro, Frank and others, to the direct conversion of undried peat into fuel-gas.

By the use of these processes, peat or lower grades of coal, totally unsuitable for other purposes, containing, in some instances, as much as 60 to 70 per cent of incombustible constituents, can be used to good advantage in the production of fuel for power generation.

Whether Mond-gas will ever be found advantageous for distribution to long distances, is questionable, because its heating value per cubic foot is rather less than that of ordinary water-gas, but this does not interfere with its efficient use in internal combustion engines.

In general, our methods for producing or utilizing gas in our cities do scant justice to the extended opportunities indicated by our newer knowledge.

Good fuel-gas could be manufactured and distributed to the individual household consumer at considerably cheaper rates, if it were not for antiquated municipal specifications, which keep on prescribing photometric tests instead of insisting on standards of fuel value, which makes the cost of production unnecessarily high, and disregards the fact that for lighting, the Welsbach mantle has rendered obsolete the use of highly carbureted gas as a bare flame. But for those unfortunate specifications, cheap fuel-gas might be produced at some advantageous central point, where very cheap coal is available; such heating gas could be distributed to every house and every factory, where it could be used cleanly and advantageously, like natural gas, doing away at once with the black coal smoke nuisance, which now practically compels a city like New York to use nothing but the more expensive grades of anthracite coal. It would eliminate, at the same time, all the bother and expense

caused through the clumsy and expensive methods of transportation and handling of coal and ashes; it would relieve us from many unnecessary middlemen which now exist between coal and its final consumer.

New Power Centers to Compete with Water-Power

The newer large-sized internal combustion engines are introducing increasing opportunities for new centers of power production where waste gas or blast-furnaces or coke-ovens, or where deposits of inferior coal or peat, are available.

If such centers are situated near tide-water, this may render them still more advantageous for some electrochemical industries, which, until now, were compelled to locate near some inland water-powers.

Nor should we overlook the fact that the newer methods for the production of cheap fuel-gas offer excellent opportunities for an increased production of valuable tar by-products, and more particularly of ammonium salts; the latter would help to a not inconsiderable extent in furnishing more nitrogen fertilizer.

It is somewhat remarkable that a greater effort has already been made to start the industrial synthesis of nitrogen products than to economize all these hitherto wasted sources of ammonia.

Our Unbalanced Methods of Agriculture

In fact, science indicates still other ways, somewhat of a more radical nature, for correcting the nitrogen deficiencies in relation to our food supply.

Indeed, if we look at this matter from a much broader standpoint, we may find that, after all, the shortage of nitrogen in the world is attributable to a large extent to our rather one-sided system of agriculture. We do not sufficiently take advantage of the fact that certain plants, for instance those of the group of Leguminosæ, have the valuable property of easily assimilating nitrogen from the air, without the necessity of nitrogen fertilizers.

In this way, therefore, the culture of certain Leguminosæ can insure enough nitrogen for the soil so that, in rotation with nitrogen consuming crops, like wheat, we could dispense with the necessity of supplying any artificial nitrogen fertilizers.

The present nitrogen deficiency is influenced further by two other causes:

The first cause is our unnecessary exaggerated meat diet, in which we try to find our proteid requirements, and which compels us to raise so many cattle, while the amount of land which feeds one head of cattle could furnish, if properly cultivated, abundant vegetable food for a family of five.

The second cause is our insufficient knowledge of the way to grow and prepare for human food just those vegetables which are richest in proteids. Unfortunately, it so happens that exactly such plants as, for instance, the soy-bean are not by any means easily rendered palatable and digestible; while any savage can eat raw meat, or can readily cook, boil or roast it for consumption.

On this subject, we can learn much from some Eastern people, like the Japanese, who have become experts in the art of preparing a variety of agreeable food products from that refractory soy-bean, which contains such an astonishingly large amount of nutritious proteids, and which, long ago, became for Japan a wholesome, staple article of diet.

But on this subject, the Western races have not yet progressed much beyond the point of preparing cattle-feed and paint oil from the soy-bean, although the more extended culture of this, or similar plants, might easily work about a revolution in our agricultural economies.

Agriculture a Branch of Industrial Chemistry

Agriculture, after all, is nothing but a very important branch of industrial chemistry, although most people seem to ignore the fact that the whole prosperity of agriculture is based on the success of that photochemical reaction which, under the influence of the light of the sun, causes the carbon dioxide of the air to be assilimated by the chlorophyl of the plant.

Possibilities of Photo-Chemistry

It is not impossible that photochemistry, which hitherto has busied itself almost exclusively within the narrow limits of the art of making photographic images, will, some day, attain a development of usefulness at least as important as all other branches of physical chemistry. In this broader sense photochemistry seems an inviting subject for the agricultural chemist. The possible rewards in store in this almost virgin field may, in their turn, by that effect of superinduction between industry and science, bring about a rapid development similar to what we have witnessed in the advancement of electricity, as well as chemistry, which both began to progress by bounds and leaps, way ahead of other sciences, as soon as their growing industrial applications put a high premium on further research.

Photochemistry may allow us some day to obtain chemical effects hitherto undreamed of. In general, the action of light in chemical reactions seems incomparably less brutal than all means used heretofore in chemistry. This is the probable secret of the subtle chemical syntheses which happen in plant life. To try to duplicate these delicate reactions of nature by our present methods of high temperatures, electrolysis, strong chemicals and other similar torture-processes, seems like trying to imitate a masterpiece of Gounod by exploding a dynamite cartride between the strings of a piano.

Some Problems for the Future

But there are endless other directions for scientific research, relating to industrial applications, which, until now, do not seem to have received sufficient attention.

For instance, from a chemical standpoint, the richest chemical enterprise of the United States, the petroleum industry, has hitherto chiefly busied itself with a rather primitive treatment of this valuable raw material, and little or no attention has been paid to any methods for transforming at least a part of these hydrocarbons into more ennobled products of commerce than mere fuel or illuminants.

A hint as to the enormous possibilities which may be in store in that direction is suggested by the recent work in Germany and England on synthetic rubber; the only factor which prevents extending the laboratory synthesis of rubber into an immense industrial undertaking is that we have not yet learned how to make cheaply the isoprene or other similar nonsaturated hydro-carbons which are the starting point in the process which changes their molecules, by polymerization, into rubber.

Nor has our science begun to find the best uses for such inexpensive and never exhaustible vegetable products as cellulose or starch. Quite true, several important manufacturers, like that of paper nitro-cellulose, glucose, alcohol, vinegar and some others, have been built on it; but to the chemist at least, it seems as if a much greater development is possible in the cheaper and more extended production of artificial fiber. Although we have succeeded in making so-called artificial silk, this article is still very expensive; furthermore, we have not yet produced a cheap, good, artificial fiber of the quality of wool.

If we have made ourselves independent of Chile

for our nitrogen supply, we are still absolutely at the mercy of the Stassfurt mines in Germany for our requirements of soluble potash-salts, which are just as necessary for agriculture. Shall we succeed in utilizing some of the proposed methods for converting that abundant supply of feldspar, or other insoluble potash-bearing rocks, into soluble potash-salts by combining the expensive heat treatment with the production of another material like cement, which would render the cost of fuel less exorbitant? Or shall the problem be solved in setting free soluble potassium salts as a by-product in a reaction engendering other staple products consumed in large quantities?

Our Ignorance Relative to Constitution of the Globe

We have several astonishingly conflicting theories about the constitution of the center of the globe, but we have not yet developed the means to penetrate the world's crust beyond some deep mines—merely an imperceptible faint scratch on the surface—and in the meantime we keep on guessing, while to-day astronomers know already more about the surface of the planet Mars than we know about the interior of the globe on which we live.

Nor have we learned to develop or utilize the tremendous pressures under which most minerals have been formed, and still less do we possess the means to try these pressures, in conjunction with intensely high temperatures.

No end of work is in store for the research chemist, as well as for the chemical engineer, who can think by himself, without always following the beaten track. We are only at the beginning of our successes, and yet, when we stop to look back to see what has been accomplished during the last generations, that big jump from the rule-of-thumb to applied science is nothing short of marvelous.

Whoever is acquainted with the condition of human thought to-day must find it strange, after all, that scarcely seventy years ago, Mayer met with derision even amongst the scientists of the time, when he announced to the world that simple but fundamental principle of the conservation of energy.

We can hardly conceive that just about the time the Columbia School of Mines was founded, Liebig was still ridiculing Pasteur's ideas on the intervention of microorganisms in fermentation, which have proved so fecund in the most epoch-making applications in science, medicine, surgery and sanitation, as well as in many industries.

Fortunately, true science, contrary to other human avocations, recognizes nobody as an "authority," and is willing to change her beliefs as often as better studied facts warrant it; this difference has been the most vital cause of her never ceasing progress.

To the younger generation, surrounded with research laboratories everywhere, it may cause astonishment to learn that scarcely fifty years ago, that great benefactor of humanity, Pasteur, was still repeating his pathetic pleadings with the French government to give him more suitable quarters than a damp, poorly lighted basement, in which he was compelled to carry on his research; and this was, then, the condition of affairs of no less a place than Paris, the same Paris that was spending, just at that time, endless millions for the building of her new Opera-Palace.

Reason for America's Slow Development of Chemical Industry

Such facts should not be overlooked by those who might think that America has been too slow in fostering chemical research.

If the United States has not participated as early as some European countries in the development of industrial chemistry, this was chiefly because conditions here were so totally different from those of nations like Germany, England and France, that they did not warrant any such premature efforts.

In a country so full of primary resources, agriculture, forests, mines and the more elementary industries directly connected therewith, as well as the problems of transportation, appealed more urgently to American intellectual men of enterprise.

Why should anybody here have tried to introduce new, difficult or risky chemical industries, when on every side more urgently important fields of enterprise were inviting all men of initiative?

Chemical industries develop along the lines furnished by the most immediate needs of a country. Our sulphuric acid industry, which can boast to-day of a yearly production of about three million tons, had to begin in an exceedingly humble way, and the first small amounts of sulphuric acid manufactured here found a very scant outlet.

It required the growth of such fields of application as petroleum refining, superphosphates, explosives and others, before the sulphuric acid industry could grow to what it is to-day.

Exports and Imports Between the United States and Germany

At present, similar influences are still dominating our chemical industries; they are generally directed to the mass production of partly manufactured articles. This allows us to export, at present, to Germany, chemicals in crude form, but in greater value than the total sum of all the chemical products we are importing from her; although it cannot be denied that a considerable part of our imports are products like alizarine, indigo, aniline dyes and similar synthetic products which require higher chemical manufacturing skill.

In this connection it may be pointed out that our exports of oleomargarine, to Germany alone, are about equivalent to our imports of aniline dyes.

Some Chemical Industries in Which the United States Was Pioneer

But all this does not alter the fact that in several important chemical industries the United States has been a pioneer. Such flourishing enterprises as that of the artificial abrasives, carborundum and alundum, calcium carbide, aluminum and many others, testify how soon we have learned to avail ourselves of some of our waterpower.

One of the most important chemical industries of the world, the sulphite cellulose industry, of which the total annual production amounts to three and a half million tons, was originated and developed by a chemist in Philadelphia, B. C. Tilgman. But its further development was stopped for awhile on account of the same old trouble, lack of funds, after $40,000 were spent, until some years later, it was taken up again in Europe and reintroduced in the United States, where it has developed to an annual production of over a million tons.

What has been accomplished in America in chemical enterprises and what is going on now in industrial research has been brilliantly set forth by Mr. Arthur D. Little.

Early Beginning of Study of Chemistry in the United States

Nor at any time in the history of the United States was chemistry neglected in this country; this has recently been brought to light in the most convincing

manner by Professor Edgar F. Smith, of Philadelphia.

The altruistic fervor of that little group of earlier American chemists, who, in 1792, founded the Chemical Society of Philadelphia (probably the very first chemical society in the world), and in 1811, the Columbia Chemical Society of Philadelphia, is best illustrated by an extract of one of the addresses read at their meeting in 1798:

"The only true basis on which the independence of our country can rest are agriculture and manufactures. To the promotion of these nothing tends in a higher degree than chemistry. It is this science which teaches man how to correct the bad qualities of the land he cultivates by a proper application of the various species of manure, and it is by means of a knowledge of this science that he is enabled to pursue the metals through the various forms they put on in the earth, separate them from substances which render them useless, and at length manufacture them into the various forms for use and ornament in which we see them. If such are the effects of chemistry, how much should the wish for its promotion be excited in the breast of every American! It is to a general diffusion of knowledge of this science, next to the virtue of our countrymen, that we are to look for the firm establishment of our independence. And may your endeavors, gentlemen, in this cause, entitle you to the gratitude of your fellow-citizens."

This early scientific spirit has been kept alive throughout the following century by such American chemists as Robert Hare, E. N. Horsford, Wolcott Gibbs, Sterry Hunt, Lawrence Smith, Carey Lea, Josiah P. Cooke, John W. Draper, Willard Gibbs and many others still living.

Present conditions in America can be measured by the fact that the American Chemical Society alone has over seven thousand members, and the Chemists' Club of New York has more than a thousand members, without counting the more specialized chemical organizations, equally active, like the American Institute of Chemical Engineers, the American Electrochemical Society and many others.

During the later years chemical research is going on with increasing vigor, more especially in relation to chemical problems presented by enterprises which at first sight seem rather remote from the so-called chemical industry.

Research in America

But the most striking symptom of newer times is that some wealthy men of America are rivaling each other in the endowment of scientific research on a scale never undertaken before, and that the scientific departments of our government are enlarging their scope of usefulness at a rapid rate.

But we are merely at the threshold of that new era where we shall learn better to use exact knowledge and efficiency to bring greater happiness and broader opportunities to all.

However imposing may appear the institutions founded by the Nobels, the Solvays, the Monds, the Carnegies, the Rockefellers and others, each of them is only a puny effort to what is bound to come when governments will do their full share. Fancy that if, for instance, the Rockefeller Institute is spending to good advantage about half a million dollars per annum for medical research, the chewing-gum bill of the United States alone would easily support half a dozen Rockefeller Institutes; and what a mere insignificant little trickle all these research funds amount to, if we have the courage to compare them to that powerful gushing stream of money which yearly drains the war budget of all nations.

In the meantime the man of science is patient and continues his work steadily, if somewhat slowly, with the mean hitherto at his disposal. His patience is inspired by the thought that he is not working for to-day, but for to-morrow. He is well aware that he is still surrounded by too many "men of yesterday," who delay the results of his work.

Efficiency vs. Waste

Sometimes, however, he may feel discouraged that the very efficiency he has succeeded in reaching at the cost of so many painstaking efforts, in the economical production of such an article of endlessly possible uses, as Portland cement, is hopelessly lost many times over and over again, by the inefficiency, waste and graft of middlemen and political contractors, by the time it gets on our public roads, or in our public buildings. Sometimes the chaos of ignorant brutal waste which surrounds him everywhere may try his patience. Then, again, he has a vision that he is planting a tree which will blossom for his children and will bear fruit for his grandchildren.

New Type of Man Evolved by Scientific Education

In the meantime, industrial chemistry, like all other applications of science, has gradually called into the world an increasing number of men of newer tendencies, men who bear in mind the future rather than the past, who have acquired the habit of thinking by well-established facts, instead of by words, of aiming at efficiency instead of striking haphazard at ill-defined purposes. Our various engineering schools, our universities, are turning them out in ever-increasing numbers, and better and better prepared for their work. Their very training has fitted them out to become the most broad-minded progressive citizens.

However, their sphere of action, until now, seldom goes beyond that of private technical enterprises for private gain. And yet, there is not a chemist, not an engineer, worthy of the name, who would not prefer efficient, honorable public service, freed from party politics, to a mere money-making job.

Government by Engineers or by Lawyer-Politicians?

But most governments of the world have been run for so long almost exclusively by lawyer-politicians, that we have come to consider this as an unavoidable evil, until sometimes a large experiment of government by engineers, like the Panama Canal, opens our eyes to the fact that, after all, successful government is—first and last—a matter of efficiency, according to the principles of applied science.

Was it not one of our very earliest American chemists, Benjamin Thompson, of Massachusetts, later knighted in Europe as Count Rumford, who put in shape the rather entangled administration of Bavaria by introducing scientific methods of government?

Pasteur was right when one day exasperated by the politicians who were running his beloved France to ruin, he exclaimed:

"In our century science is the soul of prosperity of nations and the living source of all progress. Undoubtedly the tiring daily discussions of politics seem to be our guide. Empty appearances! What really leads us forward are a few scientific discoveries and their applications."

The British Guiana gold industry has experienced a revival in the last two years, according to a consular report by Lester W. Collins. The recovery is mainly by dredging and hydraulicking. Lode mining has been disappointing. In spite of the crude methods employed, the output for 1913 was 51,765 oz.

Cyanide Practice in the Porcupine District, Ontario, Canada—I.

BY H. C. PARMELEE

General

About 100 miles northwest of Cobalt in northern Ontario lies the gold-mining district of Porcupine. A slight divide between the Cobalt and Porcupine districts separates the St. Lawrence and Hudson Bay watersheds, Porcupine being on the northerly or Hudson Bay slope. Gold mining has attracted attention to the Porcupine area for the last four or five years, following the spectacular discovery on what is now the Dome property. In 1911 the district was ravaged by a succession of forest fires which destroyed the mine and mill buildings of the Hollinger, Dome and other companies, and wiped out the town of South Porcupine; but despite these obstacles the district is now in a prosperous condition and is beginning to make a substantial gold production.

According to statistics compiled by Mr. A. A. Cole, mining engineer for the Temiskaming & Northern Ontario Railway Commission, the gold production of the Porcupine district in 1913 was valued at $4,284,928, which nearly equals the entire previous production of Ontario. The output of gold for 1913 increased 147 per cent over that of 1912, and constituted 29 per cent of the gold production of Canada and 95 per cent of that of Ontario.

FIG. 1—HOLLINGER MILL, TIMMINS, PORCUPINE DISTRICT

In marked contrast to the complex silver ores of Cobalt, those of Porcupine consist mainly of free gold in quartz and schist, accompanied by varying small quantities of sulphide minerals, principally pyrite. Metallurgy at Porcupine is accordingly much simpler than at Cobalt, and a high recovery is easily made by amalgamation and cyanidation. Nevertheless milling practice in the Porcupine district is diverse, and of the four principal mills each differs decidedly from the others in equipment and method of operation.

The Hollinger Mill

The largest and most important producing company in the Porcupine district is the Hollinger Gold Mines, Ltd. The first mill erected by the company was destroyed by fire in May, 1911, and was immediately replaced by the present plant, which commenced operating in June, 1912, and has been in successful operation since that time. The milling record for 1913 shows a total of 140,131 tons of ore treated, of which 138,291 tons was from the Hollinger mine, having an average value of $18.56 per ton. The extraction was 96.1 per cent, and the cost of milling was $1.63 per ton.

The process adopted at the Hollinger consists, briefly, in crushing and grinding the ore in cyanide solution by means of stamps and tube mills, concentrating, and separately cyaniding the concentrate and tailing. The concentrate is finely washed and dewatered in a Door three-deck washing classifier, and the tailing is treated by continuous decantation and vacuum filtration. The Merrill system of zinc-dust precipitation is used, and the precipitate is smelted and refined.

Nature and Value of the Ore

As delivered to the mill, Hollinger ore is composed of about one-fourth quartz and three-fourths schist, the latter being quite heavily mineralized with pyrite which constitutes about 5 per cent of the mill feed. Gold occurs throughout the ore in the free state and is very finely divided. It is accompanied also by some silver, the native metal having a gold fineness of 825 and a silver fineness of 125. The gross value of the ore now being treated is between $13 and $14 per ton, which is less than the average value for 1913, due to the development of large lower-grade ore bodies in the mine.

The ore is raised from the mine in 3-ton skips and delivered to the coarse-breaking plant where it is crushed successively through No. 7½ and No. 5 gyratories. A trommel screen with 2½-in. openings intervenes between the two crushers and removes the undersize from the discharge of the first gyratory. An extra man is employed on the second crusher to remove wood and steel from the ore. He takes out about 1 cu. ft. of wood per hour and more or less steel, thus reducing the possibility of breakage at the crusher and improving the mill work generally. The expense of $2.25 per day is fully justified by the results obtained.

The crushed ore is conveyed to the top of the mill by an inclined belt conveyor, 350 ft. long. The inclination is 12 deg. and the rate of travel is 250 ft. per minute. This belt has been in service for two years and has an anticipated life of two and a half years. A Merrick automatic weigher is to be installed on the belt to give an accurate record of ore delivered to the mill. A further change under consideration is to screen the ore before delivery to the battery bins, and install additional tube mills to grind the fine portion.

The battery bins have a capacity of 1000 tons. They are flat-bottomed, and the ore is discharged to the batteries through side gates. This arrangement necessitates occasional shoveling when ore is low in the bins, and it is likely that a change will be made, substituting central hoppers for the flat bottom. In that event the batteries will be equipped with belt feeders operated by Hooper attachments to the tappets.

At present the crushing equipment consists of forty 1500-lb. stamps, but the mill capacity is being increased by the addition of twenty more. They drop 6¼ in., 108 times a minute, being run rapidly in order to secure a good splash in the mortars. The height of discharge is 2 in. The screens have oblong openings—four meshes per inch in one direction and three in the other. The wires forming the warp are of lighter weight than the shoot wires, giving a screen that does not blind as easily as one in which all wires are of the same weight.

Maple-Cog Bevel-Gears on Stamp Drive

The stamps are grouped in batteries of ten, with separate 6½-in. cam shafts for each set of five stamps. A 100-hp motor provides the power ten stamps and one tube mill, a countershaft for the batteries being driven from the tube mill shaft by maple-cog bevel-gears. The substitution of maple-cog gears for steel has effected a great saving in cost. Steel gears cost $105 per set and lasted five months, whereas a set of maple cogs costs but $25 and lasts six months. Moreover, the maple-cog gears are practically silent in operation, while the steel

gears were very noisy. The motors have Reynolds silent-chain drives, but these will be replaced by Wuest gears, which are expected to prove more satisfactory in transmission of power.

Stamping in Cyanide Solution

The ore is crushed in cyanide solution added at the batteries at the rate of 3 tons per ton of ore. Under the conditions prescribed the batteries are showing an actual duty of 15 tons per stamp, being in operation 95 per cent of the possible running time. The battery discharge flows to the tube mill-classifier circuit for fine grinding, one tube mill and one Dorr duplex classifier receiving the product from ten stamps. The ratio of stamps to tube mills, 10 to 1, is the same as adopted at the Nipissing mill in Cobalt and is also in accord with the latest South African practice. The ratio of solution to ore, however, 3 to 1, may be considered low. The classifiers are 24 ft. long, being 8 ft. longer than standard machines, and are set at a pitch of 2⅝ in. per foot, thus securing gravity flow to and from tube mills.

Experiment is being made with the Globe tube mill liner, which is a sectional chilled-iron liner resembling the El Oro except that the ribs extend around the inner surface of the tube instead of lengthwise, the space between ribs tapering counter to the travel of the mill. Pebbles become firmly wedged in the space between the ribs and relieve the metal from most of the wear. While the Globe liner has not been in use long enough to determine its life, from present indications it is expected to last more than a year and reduce the cost of tube milling. At present a silex lining 5 in. thick costs $450 in place and lasts about seven months. The time lost in lining with silex is sixty hours. The Globe lining, on the other hand, costs $750 in place, but it probably will last longer than silex, and the time lost in replacing it is only eighteen hours.

Danish and French pebbles are used, at a cost of $20 and $18 per ton, respectively. The consumption of either kind is 4½ lb. per ton of ore treated.

From 75 per cent to 80 per cent of the ore is ground to minus 200-mesh in order to insure liberation and rapid dissolution of the gold. In Table I is given a screen analysis and assay value of the battery and tube mill discharges and both products of the Dorr classifier. A marked concentration will be noted in the tube mill-classifier circuit.

TABLE I.

Screen analysis	+8	+20	+40	+100	+150	+200	—200	
Battery discharge	17.1	31.3	11.6	17.0	3.5	1.0	15.5	
Tube mill discharge	0.5	0.9	1.6	41.4	15.0	5.0	35.6	
Classifier sand	9.9	12.1	7.4	42.9	15.3	4.3	8.1	
Classifier slime	...	...	0.2	5.6	11.0	4.4	78.8	
Value per Ton								Average
Battery discharge	$20.40	$9.20	$7.60	$28.40	$26.50	$31.20	$17.20	$16.17
Tube mill discharge	23.40	27.20	366.00	183.60	156.20	136.60	121.60	155.81
Classifier sand	29.30	107.20	174.80	248.40	273.60	204.36	555.00	231.02
Classifier slime	....	....	18.20	13.10	2.50	3.70	4.50	4.80

Rapid Dissolution of Gold in Tube Mills

About 70 per cent of the gold in the ore goes into solution in the tube mills, where cyanide is added to bring the solution up to a strength of 1.3 lb. KCN. A further 26 per cent is dissolved in the subsequent milling operations. Table II shows the distribution of the gold value in a ton of ore at the successive stages of the process, and the progressively diminishing value of the ore from beginning to end of treatment. Table concentrate is cyanided separately from the balance of the ore, and at the time of making the tests on which this table is based, treated concentrate was being returned to the table tailing and receiving the regular cyanide treatment. The item of $0.22 in the table represents this latter part of the concentrate.

TABLE II.
Gold Distribution per Ton of Ore

	Contained in Concentrate		Contained in Non-concentrate		Total		
Treatment	Head	Tailing	Head	Tailing	Head	Tailing	Per Cent Recovery
Tube milling	$10.92	$3.00	$2.20	$0.60	$13.12	$3.60	72.6
Concentration	3.00	0.82 + 0.22	0.60	0.55	3.60	1.59	15.3
Decantation	1.04	0.10 + 0.22	0.55	0.45	1.59	0.77	6.2
Filtration	0.32	0.19	0.45	0.33	0.77	0.52	1.9

Removal of Wood Pulp at Classifiers

Although a great deal of wood is removed from the ore at the crushers, small pieces find their way to the stamps and are crushed to a coarse pulp. This accumulates in the Dorr classifiers and is removed in a novel manner. As the slime leaves the classifier it flows onto a horizontal screen which retains the small pieces of wood, and these are removed from the screen by a reciprocating brush connected to the classifier mechanism. On the forward stroke of the rakes the brush travels clear of the screen, but is in contact with it on the backward stroke.

A mine-car full of this wood pulp is thus collected every day. It has a value of about $2 per ton. It is burned, and the ash, which has a value of $50 per ton, is added to the concentrate and cyanided. An interesting fact observed in connection with the wood pulp is that only sulphide minerals adhere to it and give it its value. As the wood is of the resinous variety and odorous of the characteristic oils of pine and spruce, it is possible that we have here conditions favorable to the selection of sulphide particles from the slime pulp, according to the principles underlying the process of oil-flotation.

Changes in Flow-Sheet

Reference is here made to the flow-sheets outlined in Figs. 2 and 3, showing certain important changes that recently have been made in the treatment. Fig. 2 gives the general outline of the method in use prior to June, 1914, and Fig. 3 embodies the subsequent changes which will be mentioned in greater detail later. The main points of difference in the method now adopted are (1) the substitution of primary Dorr thickeners for the dewatering boxes ahead of concentration; (2) the precipitation of solution overflowing these primary thickeners, and (3) the separate treatment of concentrate and tailing.

Another change in operation that has resulted in substantial economy is in the solution circuit. Formerly all of the mill solution was pumped to storage tanks at the top of the mill and then piped back to various points of application. Also, dependence was placed entirely on the shiftmen to regulate the flow of solution. According to the rearranged circuit only a part of the solution is pumped to the head of the mill, and the flow is governed by automatic floats in storage tanks. The change has greatly diminished the power consumed in pumping and has reduced the number of pumps formerly required. The tabulation below gives some comparative data on the two methods of operation.

	Foot-tons Solution Pumped, 24 Hours	Foot tons Solution Pumped per Ton Ore	Theoretical HP. Required
Former system	276,480	576	11.61
Present system	150,840	314	6.28

Separate Treatment of Mineral and Gangue

A feature of Hollinger practice that is not adopted in the other mills of the district is concentration, with separate cyanidation of concentrate and tailing. The reasons for this will be mentioned later.

Slime from the Dorr classifiers is distributed to ten

primary Dorr thickeners, 13 ft. by 6 ft., which dewater the pulp for concentration. The overflow carries off the lighter solids, amounting to about one-quarter of the tonnage, which goes to a 30-ft. by 10-ft. Dorr thickener, the overflow from which passes through Merrill clarifying presses and thence to precipitation. The underflow from this large thickener is added to the table tailing.

The thickened underflow from the primary thickeners contains about 50 per cent solution, but is diluted to 66 2/3 per cent by addition of solution from the second step of continuous decantation before distribution to the Deister concentrating tables. The wash water used in concentration is overflow solution from the thickeners in the second step of continuous decantation. It is applied at the rate of one ton for each ton of solids concentrated. The table tailing thus diluted

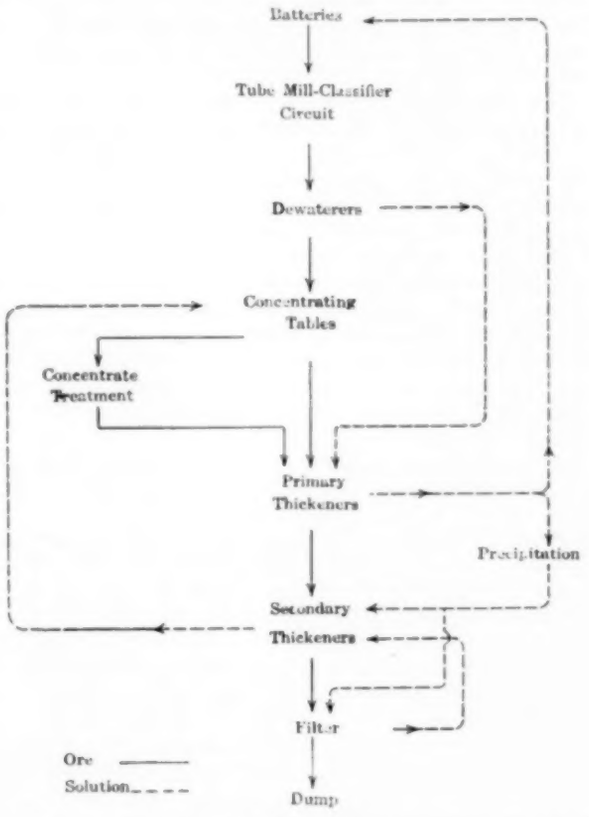

FIG. 2—DIAGRAM OF FORMER METHOD OF TREATMENT, HOLLINGER MILL

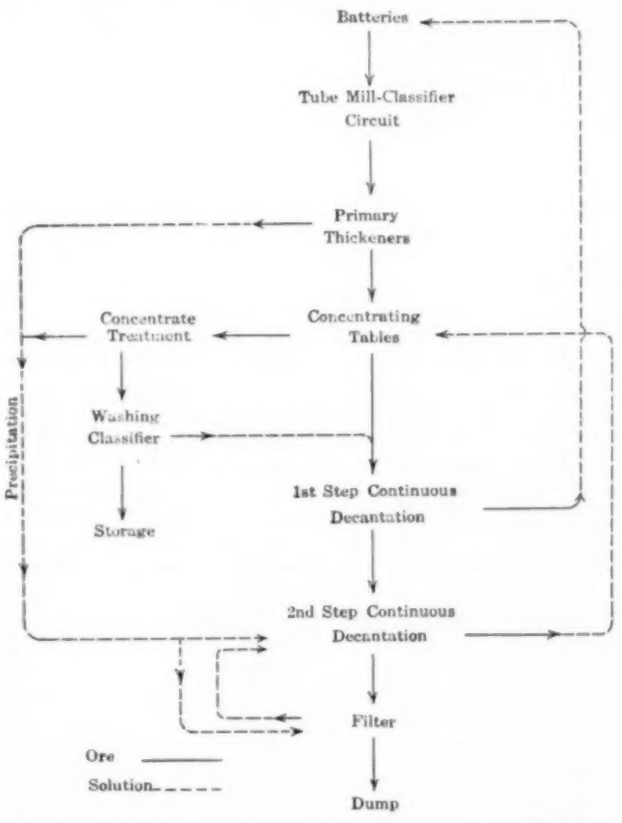

FIG. 3—DIAGRAM OF PRESENT METHOD OF TREATMENT, HOLLINGER MILL

is pumped to the first step of continuous decantation, while the concentrate is treated separately. Lime is not added to the ore until after concentration.

Cyaniding Concentrate

One of the important changes recently made in the mill practice is in the treatment of concentrate. Formerly this product was reground and treated by pan amalgamation, after which the pulp was again combined with the tailing from concentration and put through the cyanide process as outlined in Fig. 2. Recovery by amalgamation proved to be almost nothing and this step was abandoned. Further, the cyanide extraction on concentrate was not as complete as on tailing; and yet after the two had been combined it was impossible either to give the concentrate a special treatment or recover it separately from the tailing for further treatment. Consequently the system was changed as indicated in Fig. 3, and concentrate is now kept entirely separate from tailing. An incidental benefit of this change was an improvement in the work of the thickeners and filters, where the heavy sulphides formerly caused trouble.

The value of the concentrate is about $70 per ton. It is agitated for eight hours in 10-lb. cyanide solution, after which it is washed free from dissolved gold by passing through a Dorr three-deck washing classifier. The residue still has a value of about $6 per ton, but it is impossible to get a further extraction by cyaniding. Experiments indicate that by roasting and then cyaniding an additional extraction can be made and the residue reduced to a value of $1 per ton. Anticipating future treatment by this method, the concentrate residue is being stored.

No particular difficulty is experienced in cyaniding concentrate. No advantage is gained by regrinding, and the solution does not become foul when the concentrate is fresh. Chemical consumption per ton of concentrate treated is as follows: cyanide, 2 lb.; lime, 1 lb. Protective alkalinity is maintained at 1 lb. per ton.

Agitation is performed by mechanically stirring a pulp of 40 per cent solids and 60 per cent solution in Wheeler grinding pans. Aeration and thorough mixing are aided by pockets riveted to the periphery, opening in the opposite direction to the travel of the stirrers. These pockets have the effect of preventing the continuous swirl of the pulp by breaking the waves formed by the stirrers and producing counter currents. The device is very successful and well adapted to use with mechanical stirrers.

Continuous Decantation of Slime Tailing

Although a Moore vacuum filter is used for final dewatering and washing of slime, continuous decantation is relied upon for the displacement of most of the dissolved gold before the pulp is filtered. As an example of the tremendous change brought about by the adop-

tion of the decantation process, it may be stated that before it was introduced the filters were daily receiving solution valued at about $7,000, whereas after continuous decantation was adopted only $600 in dissolved gold was sent daily to the filters. This illustrates the value of continuous decantation, even in those cases where a filter is used as a final slime dewaterer.

The equipment for continuous decantation consists of four 30-ft. by 15-ft. Dorr thickeners in the first step, and four 30-ft. by 12-ft. in the second step. The first four thickeners receive the diluted table tailing, combined with wash solution from the concentrate-dewatering classifier. The overflowing solution runs by gravity back to the batteries. The thickened underflow is transferred to the second set of four thickeners and there diluted with barren solution from the precipitation presses and wash solution from the filters. The overflow from the second set of thickeners is used as wash water on the concentrating tables and the thickened underflow is filtered.

Overload Indicator for Thickeners

All of the Dorr thickeners used in continuous decantation are run at the rate of one revolution in five minutes. Power consumption is about ⅛ hp for each thickener. Unless these machines are provided with some sort of overload alarm or indicator, thick pulp may be allowed to accumulate abnormally in the bottom of the tank due to variations in amount of feed. The condition may be corrected, of course, by changing the espigot in the discharge pipe, or, where diaphragm pumps are used, increasing their speed or lengthening their stroke. But if the attendant has no warning of the increasing density of the pulp in the bottom of the tank, the vertical shaft may be twisted or the rakes broken before he can relieve the condition by increasing the underflow. Hence the value of an alarm or indicator.

The manufacturers of the Dorr thickener supply an electric overload alarm, in which the increasing resistance of the pulp on the rakes finally causes an electrical contact to be made by the thrust of the driving shaft against a steel spring. The contact rings a bell and indicates on an annunciator the particular thickener involved. An automatic pressure record is also made at the thickener by a pointer that is deflected across a dial by the thrust of the driving shaft. A pencil carried on the end of the pointer registers the maximum pressure on a card placed in the dial.

The indicator adopted by Mr. Cunningham, superintendent of the Hollinger mill, works on a similar principle but has no electrical connections. The thrust of the driving shaft against a light spring is communicated to a pointer that moves across a dial marked with a scale indicating the hp consumed in driving the rakes. The end of the pointer carries a knife-edge extending through a piece of tracing cloth mounted on the dial. As the required power increases, the knife cuts a longer slit through the cloth and thus records the maximum power used at any time during a shift.

As stated before, the power normally required in operating a thickener is about ⅛ hp. One and two-thirds horse-power will twist the vertical shaft at one-fifth r.p.m. Hence it is desirable that the power applied through the shaft shall not exceed 1/3 hp; and the shiftman is supposed to see that this figure is not exceeded and preferably not reached. The first duty of the attendant coming on shift is to inspect the indicators and report instances of excessive power as indicated by the slit in the tracing cloth. Prompt attention to this duty relieves him of responsibility for the negligence of the shiftman preceding him, while failure to make an immediate inspection and report makes it impossible to throw the blame on his predecessor and leaves him liable for the improper operation of the thickener. This system has resulted in careful attention to the work. The value of the indicators is shown by the fact that no breakage has occurred on those thickeners that are equipped with them, while several instances of damage occurred where they were not installed.

Vacuum Filtration

The underflow from the last thickeners in the continuous decantation system contains about 35 per cent moisture. It is drawn from the tanks by diaphragm pumps and discharged to the loading tanks of the Moore filter. The pumps are run from 2½-in. eccentrics at a rate of 30 strokes per minute, the eccentric motion being transmitted to the diaphragm by bell cranks. The length of stroke of the diaphragm may be regulated while the pump is running, and is variable between zero and 4 in.

The Moore vacuum filter is arranged in two units, each consisting of two 56-leaf baskets and three tanks for loading, washing and discharging, respectively. A common acid tank serves both units. The baskets are handled by an electric crane of 30 ft. span and have an aggregate filter surface of about 19,000 sq. ft.

The filter leaves are constructed of ¾-in. pipe covered with 8-oz. duck. There are two thicknesses of duck about the pipe, four at the corners of the leaf and six at the outside seams. Thus constructed the leaves last 18 months. They are made at the mill at a cost of $12.50 each, of which $7 is for material other than pipe, $3.50 for labor, $1 for assembling and $1 for header and pipe.

Acid treatment is given every five weeks with a 1 per cent commercial hydrochloric acid solution. After three weeks' use of a fresh leaf, however, it is noted that the displacement of gold solution is less efficient and the value of the residue begins to rise. It is likely that acid treatment every three weeks would give better metallurgical results and be more profitable.

A complete cycle of filtration requires 15 minutes for loading, 50 minutes for displacement with barren solution and 15 to 20 minutes for washing with water. A load of 20 tons can be accumulated in 10 minutes, but 15 minutes is the average maintained over long periods of time. The washed cake is discharged with 25 per cent moisture. It has a gross value of $0.55 per ton, the loss in dissolved gold and silver being $0.05 per ton.

The slime in the loading tanks is kept in suspension by agitating with air-lifts, one of which is placed in the center of each hopper. The lift-pipe is 6 in. in diameter and extends to within 6 in. of the bottom of the hopper. A ¾-in. air-pipe extends to within 4 in. of the bottom of the lift-pipe, being suspended loosely and connected by hose with a source of compressed air. As the air-pipe opens downward it does not become clogged with slime. Other means of keeping the slime in suspension in these tanks have proved inadequate, but the present method is successful.

Zinc-Dust Precipitation

Pregnant solution from the overflow of the primary thickeners (Fig. 3) is first partly clarified in a Dorr thickener, as already explained, and finally in two 20-leaf, 36-in. Merrill clarifying presses. These are sluiced three times a shift with a solution at 70 lb. pressure, and acid-treated every three weeks, 800 lb. commercial hydrochloric acid being neutralized in the latter operation. The equipment for precipitation consists of a zinc-dust feeder, three 20-leaf, 52-in. Merrill presses and the necessary complement of pumping apparatus.

The value of pregnant solution is about $5 per ton. The precipitation ratio—tons of solution precipitated per ton of ore—is 2.67, which is low considering the grade of ore treated. Zinc consumption is 0.6 lb. per ton of ore. Chemical consumption of cyanide is 0.2 lb. and mechanical loss 0.25 lb., giving a total of 0.45 lb. per ton of ore. Lime consumption is 2.5 lb. per ton of ore treated.

Precipitate Smelted in Blast Furnace

Precipitate from the presses is dumped into hoppers underneath, and taken thence by cars to the refinery. Here a smelting mixture is made, thoroughly mixed and allowed to "set," after which it is cut into bricks and smelted in a small blast furnace with 1½ tons of coke per ton of charge. The smelting mixture consists of 100 parts precipitate, 135 litharge, 15 borax, 5 soda ash, 4 sand and some flue dust.

Since the precipitate receives no preliminary acid treatment, the furnace slags have a high zinc content. The precipitate has a value of about $40 per pound and contains 54 per cent zinc and 5 per cent lead, the latter being derived from the lead acetate used in concentrate treatment and from the zinc dust which contains about 2 per cent lead. The slag formed in the first smelt is retreated in the furnace, after which it is sent to the mill and cyanided, an extraction of 60 per cent being made. Flue dust is formed at the rate of 60 lb. per ton of precipitate charge, or about 200 lb. monthly. The following tabulation gives the value of the various products and an average analysis for zinc and lead.

Product	Gold and Silver, Value per Lb.	Zinc, Per Cent	Lead, Per Cent
Precipitate	$40.00	54	5
First slag	0.04	35	5
Second slag	0.02	28	4
Flue dust	0.50	30	70

The base bullion is cupelled in an English cupel furnace. A cupel mixture that has proved very satisfactory, giving cupels that last for three runs, has the following composition: 100 parts fireclay, 150 cement, and 200 of screened limestone—10 + 60 mesh in size. The cupelled bullion is finally melted and refined in a Monarch oil-fired furnace and cast into bars. The resulting bullion has a total fineness of 960, of which 830 is gold and 130 silver. It contains also about 3 per cent copper and some lead and zinc.

Cost of Milling

The cost of milling operations for the year 1913 was $1.628 per ton, but this figure is abnormally high owing to irregular and inefficient operation during the early months of the year when there were serious labor disturbances in the district. Current milling cost will vary from $1.10 to $1.15 per ton, and is fairly represented in the distribution given below which is based on the treatment of approximately 15,200 tons of ore during the four-week period ending May 20, 1914. The mill was in operation 94 per cent of the possible running time. The gross value of the ore treated was $12.93 per ton, and the extraction was 95.7 per cent.

Distribution of Cost

Account	Per Ton
General milling charges	$0.045
Superintendence	.049
Tailing disposal	.017
Heating	.027
Lighting	.006
Shoveling in bins	.004
Assaying	.013
Coarse crushing	.073
Conveying (including amortization of belt)	.033
Stamping	.137
Classifying and tube milling (including 2 new liners)	.196
Concentrating	.050
Handling concentrate	.012
Treating concentrate	.031
Handling pulp	.033
Thickening	.014
Continuous decantation	.036
Filtration	.081
Neutralizing	.018
Clarifying and precipitating	.057
Smelting and refining	.058
Pumping solutions	.022
Cyanide	.074
Cleaning mill	.028
Alterations	.031
Total	$1.145

The total working cost for the period above mentioned, including mining, milling, taxes, insurance, employees' loyal service bonus, etc., was $4.219 per ton.

We are indebted to Mr. Noel Cunningham, superintendent of the Hollinger mill for his courtesy in supplying many details and data of operation published in this article.

A New Theory of the Ammonia Soda Process

BY WILLIAM MASON

The ammonical sodium chloride solution of the ammonia soda process, as carried on at present by the Solvay system, is carbonated in two stages. In the first stage it is treated with carbonic acid until about 80 per cent of the ammonia is carbonated to ammonium carbonate. In the second stage this solution if further treated with carbonic acid and sometime before the whole of the ammonia is converted into ammonium carbonate a precipitate is formed which the author finds is sodium carbonate, and is of opinion that when the whole of the ammonia becomes carbonated a reaction takes place according to the following equation:

$$(NH_4)_2CO_3 + 2NaCl = Na_2CO_3 + 2NH_4Cl.$$

Some of the sodium carbonate is precipitated in such a concentrated solution, while the remainder remains in solution and is precipitated out as sodium bicarbonate in the second stage of carbonation. In Table I are given the results of the working from a Solvay tower which clearly show that this is so, as regularly as from a solution of sodium carbonate.

TABLE I

Height in Meters	Alkalinity cc n/10 acid to neutralize 10 cc of liquor	Temperature °C	Sodium Chloride grams per 100 cc
18	41.4	39.6	24.37
17	40.3	42.3	23.55
16	38.5	43.7	22.22
15	35.8	45.0	20.88
14	33.7	48.0	19.57
13	31.2	47.5	18.40
12	28.5	47.5	17.30
11	26.6	47.3	16.25
10	24.4	47.0	15.30
9	22.8	47.0	14.25
8	21.0	46.2	13.16
7	19.1	44.2	12.26
6	17.3	43.0	11.36
5	15.9	41.5	10.54
4	15.0	38.0	9.78
3	13.4	34.0	9.10
2	12.2	32.0	8.46
1	11.2	32.0	8.46

When the precipitate begins to form, analysis shows that 50 per cent of the sodium chloride has already been decomposed and that there is 11.87 per cent of sodium carbonate in solution. A solution from the center of a Solvay tower contains about 5.83 per cent of sodium carbonate. The mother-liquor, after the separation of the sodium bicarbonate, contains only 0.53 per cent of the same. The following is an analysis of this liquor; grams per 100 c.c.

Ammonium carbonate	8.13 per cent
Sodium carbonate	0.53 per cent
Ammonium chloride	18.13 per cent
Sodium chloride	8.46 per cent

Analyses of the sodium bicarbonate produced by the Solvay system show that it also contains sodium carbonate:

Sodium bicarbonate	71.3 per cent
Sodium carbonate	4.0 per cent
Sodium chloride	0.2 per cent
Ammonia	0.5 per cent
Moisture	24.0 per cent
	100.0

The theory of this process, usually given in text books, is that the ammonia first becomes bicarbonate and then decomposed the sodium chloride, sodium bicarbonate being precipitated. But if that was so the ammonium bicarbonate, being equally as insoluble as sodium bicarbonate, would be also precipitated. Besides much heat is absorbed in the reaction of ammonium bicarbonate with sodium chloride; whereas it is well known in practice that in the Solvay tower much heat is evolved, because the precipitation of sodium bicarbonate by carbonic acid from a solution of sodium carbonate is exothermic.

When this process was first introduced by Messrs. Dgar and Hemming it was stated that: To a concentrated solution of sodium chloride was added an equivalent quantity of ammonium sesquicarbonate in order to decompose it, and a current of carbonic acid gas passed through the mixture to saturate the ammonia to make decomposition as perfect as possible, and even an earlier worker, John Thom of Camlachie, Scotland, was said to have mixed the sodium chloride with ammonium sesquicarbonate in the dry, added water and then pressed the mixture.

Now it is well known that when ammonium sesquicarbonate is dissolved in water it is resolved into the neutral carbonate and the bicarbonate, and what happened in these early operations was that ammonium bicarbonate so formed decomposed the sodium chloride, sodium bicarbonate being precipitated, and even when further quantity of carbonic acid was added, it was found that only two-thirds of the sodium chloride has been decomposed. In the Schloesing method, where solid ammonium bicarbonate is treated with a solution of sodium chloride, only two-thirds of the sodium chloride are decomposed, and the same rate of decomposition is also found in the Solvay system.

The opinion of the author is that it is the effect of the ammonium chloride which decides the quantity of sodium chloride decomposed by weakening the action of the ammonium carbonate on the sodium chloride, for when the ammonium chloride is separated from the mother-liquor of the carbonating process and it is further treated with carbonic acid a much larger percentage of sodium chloride is decomposed.

Oxford, England.

The metal production of Oregon in 1913 was valued at $1,746,402, an increase of more than 100 per cent over that of 1912. The Geological Survey states that copper was the only metal that did not show an increase in production. The gold yield was $1,627,710; silver, 179,036 fine oz.; copper, 43,330 lb.; lead, 87,207 lb.

The quicksilver industry showed decreased activity in 1913, according to figures compiled by the U. S. Geological Survey. With the exception of the production in 1908, that of 1913 was the lowest since 1860. The decline was due largely to increased foreign production, a dull market and lower prices. California was the largest producer, with 15,591 flasks of 75 lb. out of a total domestic production of 20,213 flasks. The rapid extension of the cyanide process for recovering gold and silver has materially affected the use of quicksilver for metallurgical purposes.

The specific heat of copper in the interval 0 deg. to 50 deg. C., with a note on vacuum-jacketed calorimeters, is the subject of a bulletin published by the U. S. Bureau of Standards. The bulletin was written by Mr. D. R. Harper, 3d. The determinations in the temperature range 0 deg. to 100 deg. are interpreted to indicate that the specific heat of copper (hard-drawn probably excepted) at 50 deg. is between 0.0926 and 0.0931.

Refractometry

BY G. A. SHOOK

I.—Fundamental Principles

Refraction.—Whenever a beam of monochromatic light passes from one medium, such as air, into another medium of a different *optical density*, such as glass, the beam will be bent out of its path. If the second medium has a greater optical density than the first the beam will be bent *toward the normal*, while if it is less dense it will be bent *away* from the normal to the interface, as shown in Fig. 1.

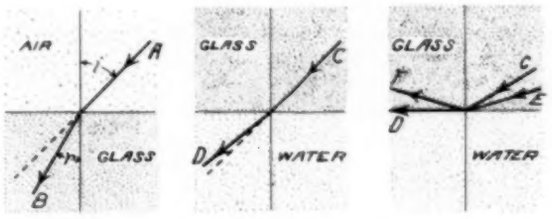

FIG. 1—REFRACTION

The amount of bending or *refracting* is slightly different for different substances. Practically all solids and liquids are optically denser than air and a few gases are optically rarer but there is no simple relation between optical density and mass density. The relation between the incident angle i and the refracting angle r is given by the simple formula

$$n = \frac{\sin i}{\sin r}$$

The constant n is known as the *refractive index* and it is an important optical constant of liquids and solids. When light passes from a vacuum into any medium the ratio $\sin i/\sin r$ is called the *absolute index* of refraction, and when it passes from one medium into another, as from air to glass, it is called the *relative index*. Unless otherwise stated it is always understood that the angle of incidence is measured in air, that is, the word "relative" is usually omitted.

The index of refraction may also be defined in terms of the velocity of light in two different media. Thus, if we represent the velocity of light by V the relative index for any substance, say glass, may be expressed by the relation

$$n_g \text{ (referred to air)} = \frac{V \text{ (in air)}}{V \text{ (in glass)}}$$

For the absolute index of air we have

$$n_a \text{ (referred to vacuum)} = \frac{V \text{ (in vacuo)}}{V \text{ (in air)}}$$

Whence the absolute index for glass is

$$n_g \text{ (referred to vacuum)} = \frac{V \text{ (in vacuo)}}{V \text{ (in glass)}}$$

$$= n_g \text{ (referred to air)} \times n_a \text{ (referred to vacuum)}$$

or

$$n_g \text{ (absolute)} = n_g \text{ (relative)} \times n_a$$

Hence if we know the index for air at the desired

TABLE I—REFRACTIVE INDICES

Substance	°C	n_d
Fluorspar	18	1.4339
Iceland spar	18	1.6584
Water	20	1.33299
Water	30	1.33248
Carbon bisulphide	20	1.6277
Ethyl alcohol (absolute)	25°	1.35941
Ethyl alcohol (5% H_2O)	25°	1.36125
Diamond		2.4699
Cotton-seed oil	15	1.4743
Sesame oil	15	1.4748
Almond oil	60	1.4535

temperature the absolute index of any substance may always be determined from its relative index. The refractive indices of a few common substances are given in Table I.

If the light in Fig. 1 were transmitted in the reverse direction *BA* instead of the direction *AB* it would follow the same path. The same is true for the path *CD*.

Now if the ray *C* is gradually oriented so that it makes a larger and larger angle with the normal, the ray *D* will likewise make with the normal a larger and larger angle and a position of *C* may be found such that the ray *D* passes along the interface as shown in the third diagram of Fig. 1.

The angle made by *C* and the normal in this case is called the *critical angle* of *incidence*. Moreover, if the light is transmitted at grazing incidents, i.e., if it passes in the direction *DC* then it will be bent into the glass as shown. The critical angle of water is about 48 deg., that of crown glass 42 deg., while that of diamond is only 24 deg.

If the incident ray makes a still larger angle, the ray *D* will be bent back into the first medium, as shown by the path *EF*.

When this condition obtains, no light is transmitted and the incident light is said to be *totally reflected*. The ray *EF* now obeys the ordinary law of reflection, i.e., the angle made by *F* and the normal is the same as the angle made by *E* and the normal.

It is not a simple matter to measure the angle of incidence and the angle of refraction directly with any

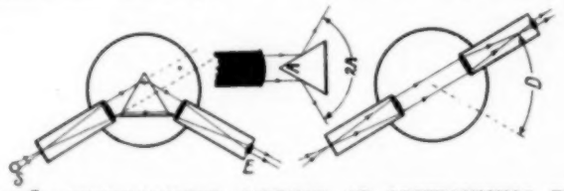

FIG. 2—SPECTROMETER METHOD OF DETERMINING THE INDEX OF REFRACTION

accuracy, so that the index of refraction, *n*, is generally determined by some indirect method. When the substance can be formed into a prism with optically plane sides, which is seldom the case, then the refractive index may be determined in terms of the angle of the prism by means of an ordinary spectrometer.

Light from a source of monochromatic radiation *S*, Fig. 2, such as a colorless gas flame in which some common salt is volatilized, falls upon the slit of the collimator and is rendered parallel by the collimator objective. This parallel beam is bent out of its path by means of a prism and thence passes through the telescope objective and forms an image of the slit. This image is finally observed by means of an eyepiece *E*.

To obtain the deviation angle one has only to set the cross-wires of the telescope on the image of the slit and to read the position of the telescope by means of the spectrometer circle when the beam is refracted by the prism and when the telescope is in line with the collimator.

The deviation, *D*, is always measured when the prism is set for *minimum deviation*; that is, when it is placed symmetrically with respect to both the incident and transmitted beams. If the prism were placed in any other position, then the deviation of the transmitted beam would be different for each position.

The position for minimum deviation is accurately obtained by adjusting the telescope and the prism so that the slit-image is in the field of view when the prism is approximately symmetrical to the collimator and to the telescope. It will now be found that upon rotating the prism slightly to the left the image passes to the left, stops, and returns to the right. This end-point, as it were, marks the position of *minimum deviation* and the cross-wires should then be set on the slit-image when the latter is in this position. This shift of the telescope, unless it is very slight, may necessitate a further small adjustment of the prism, and then again a slight movement of the telescope before the position is found such that on continuously rotating the prism to the left the image moves from the right just up to the cross-wires, stops, and returns again to the right.

The angle of the prism is obtained by setting it so that its base is approximately symmetrical with respect to the collimator as shown in Fig. 2, and then measuring the angle 2*A* by means of the telescope. The refractive index *n* in terms of the prism angle *A* and the deviation angle *D* is given by formula

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

This formula is only true when the prism is set for minimum deviation. To determine the refractive index of a liquid a hollow prism with plane parallel glass sides may be used, but there are other methods which are far more convenient.

The values of *n* thus determined depend only upon the color, or wave-length of the light used and they are always given for a particular color, generally yellow, the color of the sodium spectrum line. With a spectrometer of high resolving and dispersive power two sodium lines can be distinctly seen, and they are known as the *D* lines. The one that is the most refracted is designated D_1 and the other D_2. The wave-length of D_1 is 0.0000589 cm. and that of D_2 0.00005896 cm. In refractometric measurements the mean of these two wave-lengths is variously written 5893*A* (Angström units), 0.5893μ (microns) and 0.00005893 cm.

In all cases it is necessary to specify for what wave-length the refractive index is determined and this may be done in any of the above ways. The variation of *n* with wave-length in the case of flint glass and carbon bisulphide is shown in Table III.

From Table I it is readily seen that the difference in *n* for different substances is so small that quite an accurate measurement is necessary in order to make the determination of this constant of any practical value in industrial work. While the spectrometer is used for absolute measurements it is not practical for industrial work since considerable care in manipulation is necessary in order to obtain accurate results and, moreover, to carry out a determination a large amount of the material to be tested is required.

Most of the instruments now in use utilize the phenomenon of total reflection. Some of these instruments are so constructed that white light may be used and a special illuminating device is therefore unnecessary, but with others monochromatic light must be used.

While it would be more logical to reduce all refractometric measurements to the refractive index, *n*, it is in some cases more convenient to give the refraction in terms of an arbitrary scale division. Most of the important instruments, however, that are provided with arbitrary scales are also provided with tables, so that the scale readings of a particular instrument can be converted into refractive indices.

In all work, therefore, it is very important to state the refraction in terms of the index and preferably for the *D* line. The user of any instrument provided with an arbitrary scale can readily transform refractive indices into scale divisions to suit his own work.

Dispersion.—If the ray of light *AB* incident on the interface, Fig. 1, is not monochromatic, i.e., not of a single color such as the yellow light emitted by a sodium flame then it will be spread out or *dispersed* in the second medium as shown in Fig. 3.

The blue rays are the most refrangible and the red the least.

The amount of spreading out and the extent to which all of the rays are refracted depends both upon the angle of incidence and the material of the medium. Thus for the same angle of incidence the refraction is different for water and for glass, but for the same material, say glass, the refraction is different for different angles of incidence.

When the slit of a spectrometer is illuminated by white light one sees, on looking through the telescope, a continuous succession of images of the slit; that is,

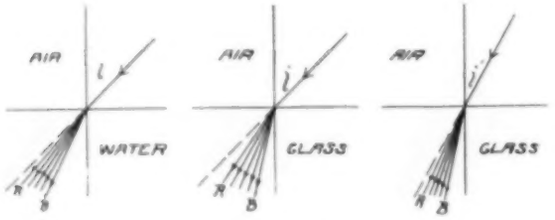

FIG. 3—DISPERSION

the slit-image is drawn out into a band of color. Fraunhofer identified a large number of the most conspicuous absorption lines in the solar spectrum with the emission lines of familiar terrestrial elements and these are designated by the letters *A*, *B*, *C*, etc. The wave-lengths corresponding to a few of these lines are given in Table II

TABLE II—WAVE-LENGTHS OF THE FRAUNHOFER LINES

A'	7677 A°	Red	K
A	7605		
B	6867		
C	6563	Hα	Red
D	5893	Yellow	Na
E	5270	Green	
F	4861	Hβ	Blue
G'	4341	Hγ	"
h	4103	Hδ	"
H	3969		
K	3934		

In refractometry indices of refractions are generally referred to one of these lines. For the same wave-length interval the difference in angular deviation is by no means the same throughout the spectrum, but in general the shorter wave-lengths are separated the most. The difference between the refractive indices for any two wave-lengths or colors is called the *dispersion.* For a given substance the dispersion is different for different parts of the spectrum and for a given region of the spectrum the dispersion will be quite different for different substances. Thus for flint-glass the refractive index for the *C* line is 1.618 and that for the *D* line is 1.628, therefore the dispersion for the interval *D-C* is $n_d - n_c = 0.010$.

Since most of the visible spectrum is included between the *C* and *F* lines, the dispersion for this region, namely, $n_f - n_c$, is often taken as a characteristic constant of a solid or a liquid in the same way as we consider the refractive index for, say, the *D* line. This factor, $n_f - n_c$, is sometimes called the *mean dispersion* and sometimes the *medium dispersion*, while the interval $n_d - n_c$ or $n_f - n_g$, etc., is known as the *partial dispersion.*

Again, if the index of refraction is measured over any other range, say, from *A* to *H*, the dispersion $n_A - n_H$ is spoken of as the *medium dispersion.* Since the interval *C* to *F* comprises about all the visible spectrum, it is proportional to the dispersion of the entire visible spectrum, hence the notation *medi-dispersion.*

In general a substance which has a large n_d will have a large medium dispersion, $n_f - n_c$, but this does not necessarily follow by any means. Let us consider, for example, the case of flint glass and carbon bisulphide. The indices for four lines are given in the following table:

TABLE III

FLINT GLASS	
C 1.624	1.618
D 1.628	1.628
F 1.641	1.652
H 1.674	1.689

It is seen from this table that for the *D* line value of the index of refraction is the same in both cases, but the total dispersion for flint glass is 0.050 and for carbon bisulphide it is 0.071. Moreover, the partial dispersions for the two cases bear no simple relation to the complete dispersions.

The partial dispersions are, however, in each case greater for carbon bisulphide than for flint glass; that is, the large complete dispersion is accompanied with large partial dispersions, although there are even exceptions to this. In the case of carbon bisulphide and monobromonaphthaline the complete dispersion, *A* to *H*, for the latter is very much larger than for the former, while the partial dispersions *D* to *F* and *F* to *G'* are slightly less.

From the data on Jena glass, Table IV, it is seen that while the second substance has a slightly larger mean dispersion than the first its refraction for the *D* line is much less. Moreover, while the third substance has a higher mean dispersion than the second its index of refraction for the *D* line is larger than the second.

TABLE IV—JENA GLASS

	n_d	Mean Dispersion C to F
Medium phosphate crown	1.5590	0.00835
Silicate crown	1.5169	0.00844
Crown of high dispersion	1.5149	0.00943

Manifestly one cannot infer that because the refraction for the *D* line is high the total dispersion will consequently be high, or conversely.

It is thus seen from the above examples that dispersion plays an important rôle. For instance, two substances under analysis may give the same value for n_d, but they may not show the same mean dispersion so that while a determination of n_d would not tell us anything of the composition of a particular substance, a measurement of its dispersion might be of value.

Index Refraction and Density.—That the index of refraction varies considerably with the physical state of a substance has been known from the beginning of the history of light theories. The two most important changes are density and temperature. Laplace derived, from the emission theory of light, the expression

$$\frac{n^2 - 1}{d} = k = \text{const.}$$

Considerably later Gladstone and Dale determined empirically the relation

$$\frac{n - 1}{d} = k' = \text{const.}$$

Finally a third formula

$$\frac{n^2 - 1}{d\,(n^2 + 2)} = k'' = \text{const.}$$

was deduced from Maxwell's magnetic theory of light by a number of physicists.

These formulæ have been tested by many experiments, but most of the data has been derived from liquids. The temperature correction for either of these formulæ is small and is generally neglected except in refined work. The last two equations are now more generally used than the first and the second is preferable because of its simplicity.

The constant k, k' or k'' is sometimes called the *specific refractive power* and the product of the specific refractive power and the molecular weight of a substance is called the *molecular refractive power*.

In the case of an organic solution or an electrolyte the refractive index does not increase at the same rate as the concentration. This may be due to the fact that hydration generally takes place.

Moreover, when a salt is dissolved in water the change in volume per unit quantity of salt is different for different concentrations. Therefore, when the density changes due to a change in concentration the refraction may still be a linear function of the density while it bears no simple relation to the concentration. If the concentration is, however, a linear function of the density, which is sometimes the case for limited ranges of concentration, then the refraction will increase at the same rate as the concentration. The above equations will also hold true when a change of density is effected by a temperature change.

When a salt is dissolved in water, the relation between the specific refraction of the salt k, that of the water k_w, and that of the solution k_s is given by the simple relation

$$kx + k_w\,(100 - x) = 100\,k_s$$

where x is the per cent of concentration. Assuming that k_w does not change when the salt is dissolved into it, the specific refraction k may be determined from a measurement of the refractive index of the solution.

Moreover, the sum of the *atomic* refractions of the elements of a compound is equal to the *molecular* refraction of the compound and this relation may be expressed by the simple equation

$$R = xr + x'r' + x''r'' \quad . \quad . \quad . \quad .$$

where R is the molecular refraction, r is the atomic refraction, and x the number of atoms that enter into composition.

In Table V are given the molecular refractions of lithium chloride, sodium chloride, etc. This data was taken from the works of Baxter, Boylston and others on "The Refractive Powers of the Halogen Salts of Lithium, Iodine and Potassium in Aqueous Solutions." This work was carried out with a Pulfrich refractometer and by means of a *differential method* an accuracy of two units in the fifth decimal place was obtained. The values given in Table V are all for the same concentration.

TABLE V—MOLECULAR REFRACTIVE POWERS

	Cl	Br	I
Li	8.75	12.29	19.00
Na	9.25	12.80	19.43
K	11.35	14.19	21.48

This additive law of the atomic refractions has been the subject of much discussion and it is apparently only approximately true. We may at least, however, get a rough estimate of the molecular or atomic refraction of a number of elements that could not be determined otherwise. An example may be worked out from the above data. Since the molecular refraction varies slightly for different concentrations it is logical to compare only values obtained for the same concentration.

The value of the atomic refraction of hydrogen obtained for the D line is 1.03 and a recent value for the molecular refraction of hydrogen chloride is 8.53, therefore, the atomic refraction of chlorine is $8.53 - 1.03 = 7.50$.

We may now write

$$r\,(\mathrm{Na}) + r\,(\mathrm{Br}) = 12.80$$

and

$$r\,(\mathrm{Na}) + r\,(\mathrm{Cl}) = 9.25$$

whence

$$r\,(\mathrm{Br}) - r\,(\mathrm{Cl}) = 3.55$$

or

$$r\,(\mathrm{Br}) = r\,(\mathrm{Cl}) + 3.55 = 7.50 + 3.55 = 11.05$$

In a similar manner we obtain for iodine

$$r\,(\mathrm{I}) = 17.68$$

We can also determine the atomic refraction of Li, Na, or K. For example, the molecular refraction of NaCl is 9.25, whence the atomic refraction of Na is $9.25 - 7.50 = 1.25$. We may, of course, determine the atomic refraction of Na from NaBr or NaI.

Index of Refraction and Temperature.—The relation between the refractive index and the temperature of a substance is practically linear and may be expressed by the formula

$$\frac{n}{a} + \frac{t}{b} = 1.$$

That is, the change in the index of refraction from 20 deg C. to 21 deg. C. is the same as the change from, say, 42 deg. C. to 43 deg. C, etc.

The constants a and b must be determined for a particular wave-length of light and they will also be different for different substances, although for certain classes of liquids, for example, the ordinary oils and fats, the change in index of refraction per degree C. is practically the same as is shown in Table VI (Tolman and Munson):

TABLE VI—TEMPERATURE CORRECTIONS FOR OILS

Oil	Decrease in index per °C
Linseed	0.00037
Cotton	0.00037
Peanut	0.00037
Corn	0.00036
Sesame	0.00037
Olive	0.00037
Rape	0.00036
Mean value	0.000365

If, therefore, the refractive index of an oil is 1.47365 at 20 deg. C., at 30 deg. C. it will be 1.47000.

In the case of instruments constructed with arbitrary scales, each division of the scale does not represent necessarily the same increment of refraction so that different corrections must be applied to different parts of such a scale. This will be considered in the next article on Instruments.

Although a temperature correction can be effected, it is always desirable to carry out the determination of the refractive index at some fixed temperature, say, 25 deg. C. This is not possible for two reasons; in the first place, while an instrument may be maintained at a constant temperature without much difficulty, rather elaborate heating apparatus is necessary in order to control the temperature, and, secondly, tables of indices of refraction are not made out for a standard temperature, so that data must be taken for whatever temperature it has been worked out and the necessary temperature correction made.

That the temperature correction changes markedly with the wave-length of the light used is shown clearly by Table VII on dimethylaniline (Falk).

TABLE VII—REFRACTION INDEX OF DIMETHYLANILINE AND TEMPERATURE

Spectral line	Index of refraction	Change per °C
C	1.55296	0.000495
D	1.55968	0.000499
F	1.57765	0.000519
G'	1.59489	0.000539
Density	.....	0.000825

The change which takes place in the dispersion with temperature change is also of interest (Table VIII).

TABLE VIII—DISPERSION AND TEMPERATURE

	D-C	F-D	G'-F
Dispersion at 10°	0.00666	0.01810	0.01722
Dispersion at 80°	0.00638	0.01670	0.01582

Density and Temperature.—The variation of density with the temperature may also be expressed by an equation of the form

$$\frac{d}{a'} + \frac{t}{b'} = 1$$

The effect of temperature change upon refractive index, density, and the specific refraction is shown in Table IX, taken from the work of Falk. This work was all carried out by means of a Pulfrich refractometer.

Table IX—Dimethylaniline

°C	n_c	d	k	k'	k''
10	1.55680	0.9648	1.4756	0.5771	0.3335
40	1.54195	0.9401	1.4654	0.5765	0.3347
80	1.52215	0.9070	1.4520	0.5757	0.3363

The density of a solution is, of course, not a simple function of the concentration and therefore there is no simple relation between index of refraction and concentration.

In many cases, however, by means of tables, the concentration can be determined from the density. Since the index of refraction of a liquid can be accurately determined with far greater ease than the density, it is often advantageous to estimate concentrations by means of the refractometer.

In the case of aqueous alcohols, tables have been worked out giving the per cent of water in terms of the refractive index or in terms of the scale divisions of some particular instrument, for instance, the Zeiss refractometer, which is particularly adapted to alcohols. In Table X a few values of such a concentration table (Andrews) are given.

Table X—Alcohol

% H_2O	N_d at 25° C	Zeiss Reading
0	1.35941	85.30
1	1.35984	86.49
2	1.36024	87.60
3	1.36061	88.63
4	1.36094	89.59
5	1.36125	90.45

It will be observed from this table that the difference in the Zeiss reading for small changes in concentration is sufficiently large to permit a very accurate determination of the concentration. As might be expected, there is not a constant difference in index of refraction for each per cent difference in concentration. The maximum value of the index is for a solution containing 20.7 per cent H_2O.

Another important use of the refractometer, in the case of alcohols, is the determination of the amount of methyl alcohol present in any mixture of ethyl and methyl alcohol. Here a determination of the density is of no value whatever, since the density of absolute methyl and absolute ethyl alcohol is practically the same. Moreover, when they are diluted with the same amounts of water their densities are identical. However, the refraction for ethyl alcohol is much greater than the refraction for methyl alcohol.

From a table given by Leach and Lythgoe, who were the first to make out data for alcohols, a 20 per cent solution of methyl alcohol gives a Zeiss reading of 26.5, while the same concentration of ethyl alcohol gives a reading of 50.5, and the two readings corresponding to a 50 per cent solution are 39.8 and 90.3. For small concentrations the difference is not so great.

It is thus seen that it is a comparatively easy matter to identify the two alcohols by means of the refractometer. If, therefore, the strength of a solution of alcohol is determined from its density, by means of such a table one can determine at once whether the alcohol is methyl or ethyl. Moreover, if it is a mixture, a simple calculation will enable one to determine the per cent of each present.

One of the examples that they give may be of interest. From the analysis of a lemon extract an 18.38 per cent alcohol was found and it gave a reading of 35.8 on the Zeiss refractometer. From their table the readings corresponding to an 18.38 per cent alcohol are 47.2 for ethyl and 25.4 for methyl alcohol. Assuming that the addition of methyl alcohol to ethyl alcohol decreases the refraction in direct proportion to the amount added, the per cent of the methyl alcohol present in the mixture is evidently

$$\frac{47.2 - 35.8}{47.2 - 25.4} \times 100 = 52.3.$$

This classical example is cited to illustrate the use of the refractometer where other simple methods of analysis fail.

No references have been given to tables of indices of refraction, temperature corrections, etc., since these may always be found in books on food analysis or in such standard works as the Landolt-Börnstein Physickalisch-Chemische Tabellen.

Professor Féry has prepared tables of refractive indices of the chief solutions of salts employed in laboratories. Such observers as Chéneveau, Bary, Labrosse, Lebrasseur and Grassot, Warrick (London), Coffignier, Dr. Nicloux, Professor Demerliac, Tixier have also added to the earlier tables and their results are published in part in the Memento du Chimiste of MM. A. Haller and Ch. Girard.

Among other things of importance included in these tables are the following:

Solutions of sulphuric, nitric, hydrochloric and acetic acids.

Alkaline solutions of sodium and potassium.

Solutions of sodium carbonate, of the chlorides of sodium, potassium, ammonium, and zinc.

Solutions of the sulphates of iron, copper, zinc, aluminium and lithium, of potassium bichromate and hyposulphite of sodium.

Mixtures of water and alcohol (ethyl and methyl).

Mixtures of water and glycerine.

Solutions of citric, tartaric, oxalic and tannic acids.

Refractive indices of various organic compounds, refractive indices of essential oils employed in perfumery.

Various other oils, of which a large number of tables have been prepared owing to the industrial importance of this method of analysis.

The following articles may also be of interest: Thèse de M. A. Fancon, "Indices des solutions salines équimoléculaires"; Thèse de M. Chéneveau, "Recherches sur les propriétés optiques des dissolutions et des corps dissons." In both of these articles constant use has been made of the Féry refractometer.

In the next article of this series the most important instruments will be considered in detail.

University of Michigan,
Ann Arbor, Michigan.

Chlorate of Potash in Norway.—The Frederiksstad Elektrokemiske Fabriker have acquired a secret process for the production of potassium chlorate, in commercial use at present in the south of Europe. Norway has imported heretofore some hundred tons of this product a year. Similar factories, using older processes, are in operation in Finland and in Sweden. The Frederiksstad Elektrokemiske Fabriker has met with much sympathy from the town of Frederiksstad whereby they have secured a favorable power contract under the contract of the town of Frederiksstad with the power company of Hafslund.

The **De Laval Separator Company**, New York, have installed an experimental creamery, as part of their experimental department, in Poughkeepsie, N. Y. It is probably the only creamery in the United States where practically all the milk is separated by hand separators. In addition to cooling vats, pasteurizers, Babcock testers, etc., it also includes the necessary apparatus for making chemical analyses, acid determinations, and physiological investigations and is equipped with special apparatus designed particularly for making delicate tests.

Titanium-Nitride in Steel

BY GEORGE F. COMSTOCK

In the course of many microscopic examinations of rail steel, both untreated and treated with ferro carbon-titanium, certain hard non-metallic spots came to be recognized as being fairly characteristic of the treated steel and never found in the untreated. These spots were usually very minute, requiring a magnification of at least 200 diameters (preferably 400) to show them clearly; they were never found segregated in streaks or groups, but were always quite evenly scattered throughout the rail's section; they were never elongated in the direction of rolling, but often had angular outlines though usually somewhat rounded in shape; it was difficult to polish a sample containing these spots without pitting, owing to their great hardness as compared with the surrounding metal; and finally when seen with the pure white light of a carbon arc on the ground glass of the metallographic camera, these spots appeared bright pink in color. Their apparent hardness and color were their most characteristic qualities, and it was found that practically all titanium-treated rails contained these pink spots in varying amounts, except those in which the titanium had not produced its usual effect in reducing segregation. The above statement is based on our experience with about forty plain and treated "A" rails (rails made from the top parts of ingots), which have been thoroughly tested and examined here.

The photomicrographs of Figs. 1 and 2 show some of the typical pink inclusions as found in treated rail steel. The section from which these photomicrographs were made was cut parallel to the direction of rolling of the rail, and the lack of elongation of the angular pink inclusions is well shown by comparison with the long thin streaks of manganese sulphide.

The fact that these pink inclusions are never found in steel that has not been treated with titanium proves that titanium must be necessary for their production. An attempt has been made to discover the composition of this hard pink substance, but owing to its finely divided condition and the very minute quantity present in any given sample of treated steel, no pure sample could be obtained for direct chemical analysis. The method followed in attacking this problem was the rather crude one of incorporating various compounds of titanium in samples of untreated rail steels until some substance was found which appeared similar in all respects in a polished section to the characteristic "pink inclusions." Titanium sulphide, carbide and nitride naturally suggested themselves as the compounds most worthy of a trial, and it was also suggested that the spots might be alumina colored by titanium in some form. Practically all the melts of steel with the above compounds were made at the Rensselaer Polytechnic Institute at Troy, N. Y., by Prof. M. A. Hunter, and the titanium sulphide, carbide and nitride used were also supplied by him. The melts were made in an electric furnace in a vacuum, the residual atmosphere in the furnace being carbon monoxide.

The sulphide of titanium was the first compound investigated, and some untreated rail steel was treated with it, but the pink inclusions were not found. Photomicrograph 3 shows this steel as melted by Prof. Hunter in a carbon crucible without any addition. Ordinary manganese sulphide inclusions were numerous in it. Fig. 4 shows this same steel treated in an alundum crucible with ferro carbon-titanium. The characteristic pink inclusions were found here, and are represented in the photomicrograph by the dark angular spots. The faint small rounded spots were also pink in color, but much paler, and are probably some different substance, the identity of which is not important since these pale pinkish rounded spots are not found in ordinary steel. Fig. 5 shows this same steel treated in a carbon crucible with titanium sulphide, and Fig. 6 shows the result of the same treatment done in an alundum crucible. The spots shown in both these photomicrographs had the grayish color typical of manganese sulphide. By comparison with Fig. 3 it is seen that the addition of titanium sulphide to the steel has increased the amount of the ordinary sulphide inclusions and has caused them to be more finely divided, although their color was not changed. Evidently therefore titanium sulphide must mix with the manganese and iron sulphides if it is present at all in melted steel, and it cannot be the substance forming the "pink inclusions."

Titanium carbide was the next substance tried in the endeavor to find the composition of these inclusions. Fig. 7 shows the structure of some fairly pure titanium carbide. The large rounded grains there shown are of a pale violet color, while the streaks between them are very light yellow. The entire mass is very hard and brittle, and the black spots are pits broken out in grinding the section, and which could not be entirely removed in polishing. The violet gray material is the carbide of titanium, and the yellowish material is probably iron carbide or cementite. Fig. 8 shows some steel that was treated with titanium carbide. The smooth areas near the top of the print are carbide, and the spotted substance at the bottom is the steel, full of little dots of carbide. At the boundaries between the large masses of carbide and the steel a feathery, mixed structure was found, as shown throughout the center of this print. This peculiar appearance of the boundaries, together with the occurrence of the small spots of carbide through the steel, indicates that the carbide dissolved in the melted steel, and was more soluble when hot than when cold. Had the mixture been kept long enough at a high temperature, the carbide would eventually have become evenly distributed throughout the steel. None of the characteristic "pink inclusions" were found in this metal, and therefore they cannot be titanium carbide.

The structure of impure titanium nitride is shown by Fig. 9. This substance like the carbide, is very hard and brittle, and it is very difficult to remove by polishing the pits formed in it when the section is ground. The chief part of this alloy, appearing dark gray in the photomicrograph, is bright yellow in color and is probably pure nitride. The light areas shown in the photomicrograph probably represent carbide, and the black areas oxide.

Figs. 10 to 13, inclusive, show samples of rail steel treated with large amounts of titanium nitride. Fig. 10 shows a melt made by Prof. Hunter in an alundum crucible in a vacuum furnace, a large angular fragment of nitride being shown embedded in the steel. This fragment had the characteristic pink color and hard appearance of the "pink inclusions," and smaller typical "pink inclusions" were found scattered in the steel. This steel was from an untreated rail, which had previously been carefully examined and found free from pink spots, like all other untreated steels. Thus the remelting with titanium nitride produced in this case the typical "pink inclusions." In other parts of this small melt some ordinary yellow nitride masses were found, and since the melt was made in an alundum crucible, it was thought possible that the pink color might have been produced only where alumina from the crucible (or perhaps in the original steel) had combined with the titanium or the nitride.

In order to obtain a melt free from alumina as well as from carbon in excess, a small crucible was made from a piece of rail which was known to contain no alumina, and in it some nitride and drillings from the

same steel were fused by an arc from an electrode rod of the same alumina-free steel. In this way it was certain that no alumina could be in the product, and the only carbon present was that in the steel used which was from a Bessemer rail. Photomicrographs Nos. 11, 12 and 13 show portions of this melt. In places the nitride seemed to have preserved its original yellow color, but a large amount of it showed the characteristic bright pink color of the "pink inclusions." In places this pink nitride was extensively marked with a dark gray substance, which is believed to be oxide, and Fig. 11 shows the structure where the dark substance was specially abundant. The color of the nitride even here where it was so much oxidized was on the whole distinctly pink. Fig. 12 shows a part of the melt where there was less oxide, and where some smaller particles of the pink nitride were embedded separately in the steel. The steel near the large masses of nitride was full of very small pink inclusions, showing that the nitride dissolved in the steel to a slight extent. Fig. 13 shows some of these very small but typically pink inclusions. It must be remembered, however, that this melt was made with an electric arc, so that extemely high tempeatures were attained in parts of the crucible. Photomicrograph, Fig. 10, compared with Fig. 8, shows that at temperatures sufficient to melt steel the nitride does not readily dissolve while the carbide does.

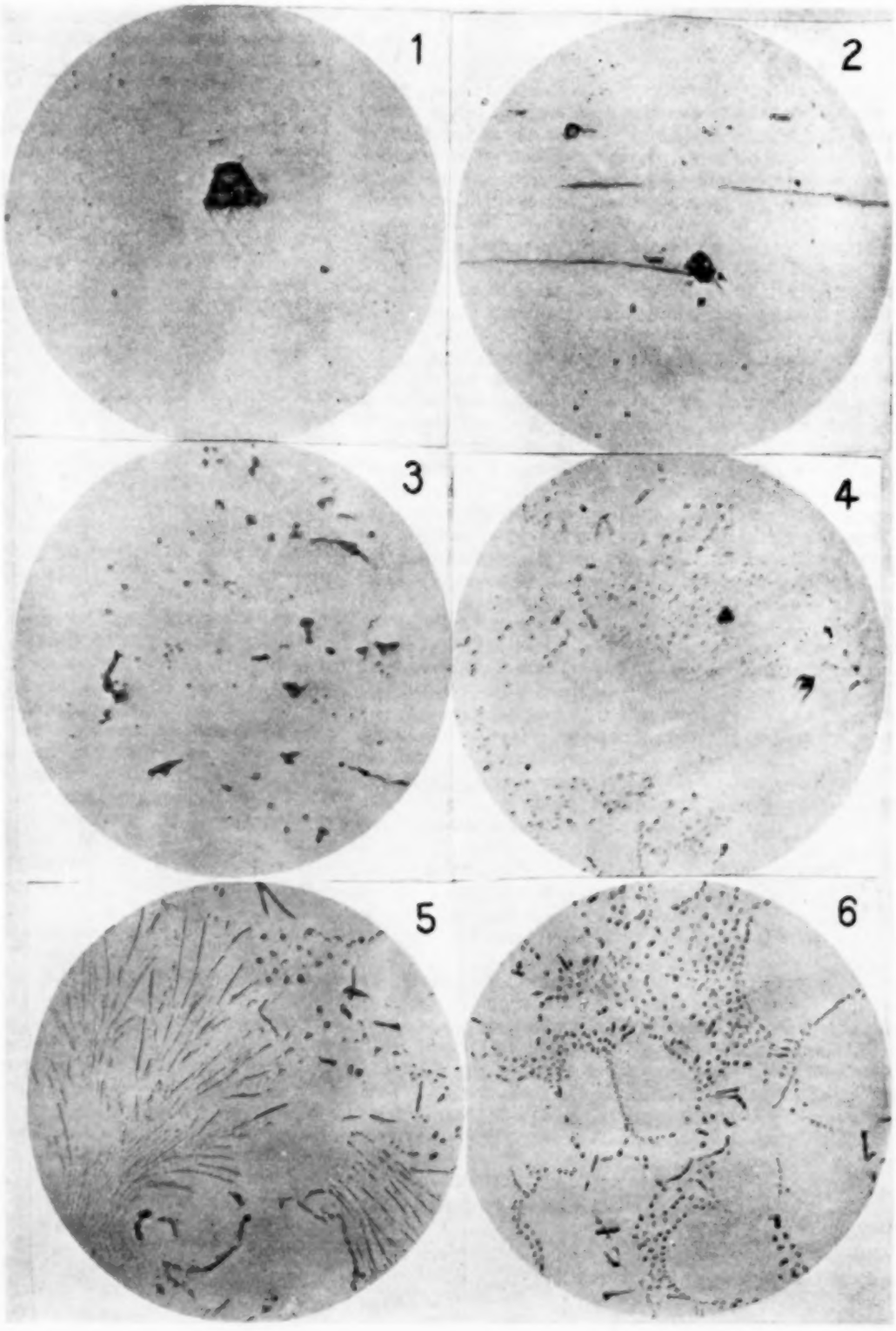

Fig. 1: Longitudinal section in web of titanium-treated rail, magnified 400 diameters, showing angular pink inclusion. Fig. 2: Longitudinal section in web of titanium-treated rail, magnified 400 diameters, showing angular pink inclusions and long fibres of manganese sulphide. Fig. 3: Untreated steel, with manganese sulphide inclusions, magnified 200 diameters. Fig. 4: Treated steel with two kinds of pink inclusions, pale and darker, magnified 200 diameters. Fig. 5: Steel containing manganese and titanium sulphides, magnified 200 diameters. Fig. 6: Steel containing manganese and titanium sulphides, magnified 200 diameters.

Fig. 14 shows a large skeleton crystal, found in ferro-titanium, made by the alumninothermic method, which had the characteristic color of the "pink inclusions." By dissolving this alloy in acid a residue was obtained of yellowish pink crystals which were found to contain nitrogen. This is in agreement with the view that the pink crystals found in steel are titanium nitride.

It seems evident from the above experiments that the "pink inclusions" found in titanium-treated rail steel,

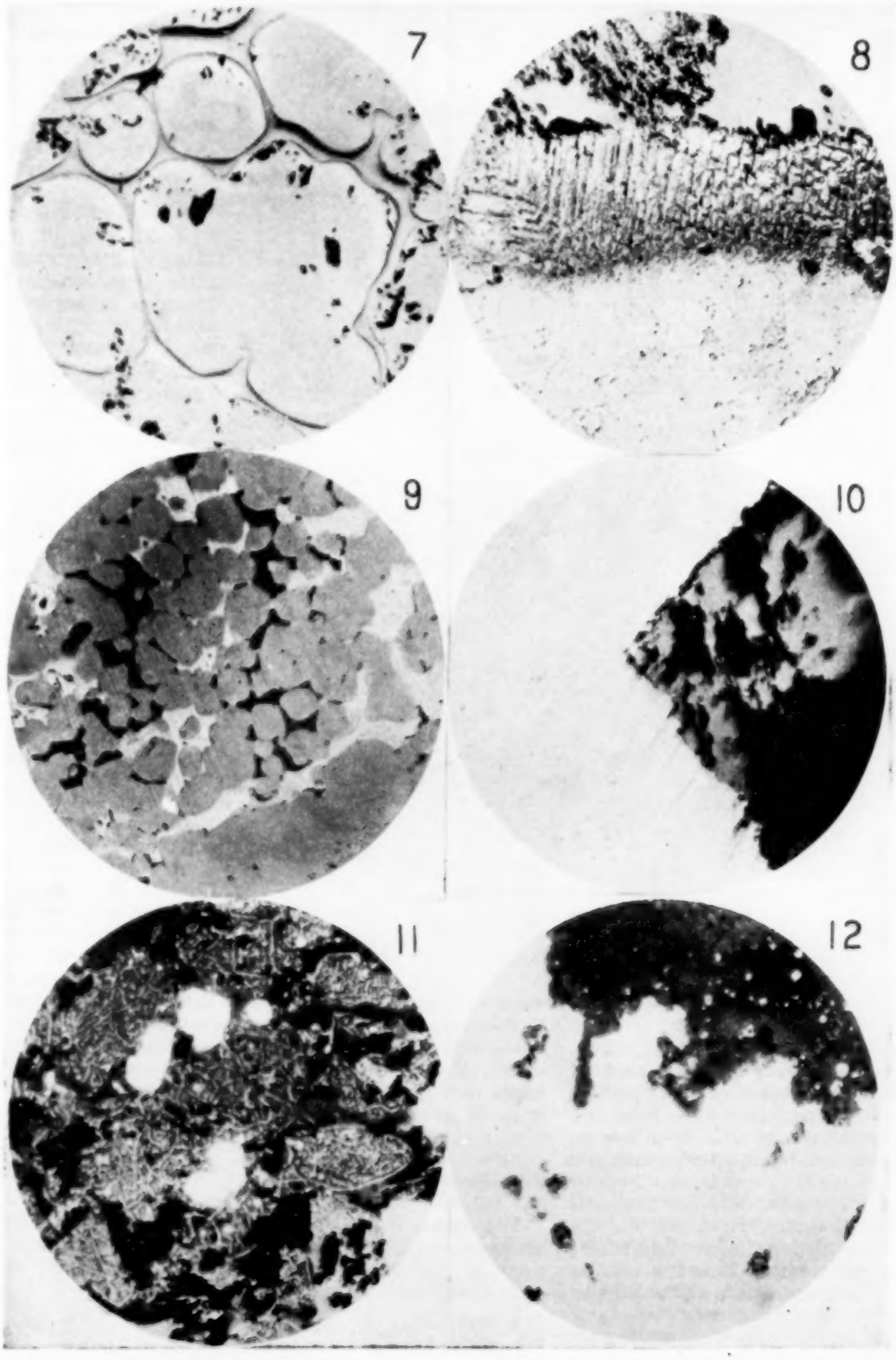

Fig. 7: Titanium carbide, light violet grains surrounded by yellowish-white network, magnified 100 diameters. Fig. 8: Titanium carbide above, dissolving into steel below, magnified 200 diameters. Fig. 9: Titanium nitride, bright yellow grains surrounded by light and dark gray substances, magnified 100 diameters. Fig. 10: Steel melted with titanium nitride in alundum crucible, magnified 400 diameters. Fig. 11: Titanium nitride melted and oxidized in steel crucible, magnified 400 diameters. Fig. 12: Pink titanium nitride in steel, magnified 400 diameters.

and not found in untreated steel, are composed largely if not entirely of titanium nitride, and that while carbon and iron may enter into their composition, alumina does not. Photomicrographs Figs. 15 and 16 are of interest in this connection. Fig. 15 shows an alloy of "pure" Swedish iron with 5 per cent of pure metallic titanium, and Fig. 16 shows a similar alloy of Swedish iron with ½ per cent of aluminothermic ferrotitanium alloy. These alloys were melted in a vacuum furnace and in alundum crucibles. The angular inclusions shown in Fig. 15 had the yellow color of titanium nitride, and the small rounded spots were very pale pink like the inclusions shown in Fig. 4. The metallic titanium must have combined with the nitrogen in the Swedish iron to form the yellow nitride, and possibly the total absence of carbon from this alloy is the reason for the pink color not being shown. Photomicrograph 16 shows a streak of alumina inclusions, their color being very dark blue. No pink or yellow inclusions were seen in this alloy, although some titanium was present with aluminium. Alumina has been identified in ordinary steels and occurs in very small dark bluish particles, very hard to polish without pitting, and often arranged in streaks.

It is unfortunate that chemical confirmation cannot be obtained for the identification of the "pink inclusions" as titanium nitride, but no reliable method is known for the quantitative determination of nitrogen in this form. An average of many nitrogen determinations made here by an improved method on titanium-treated rails shows a distinctly lower amount present than in untreated rails, but this difference in nitrogen content of the metal may be due to the locking up of some nitrogen by titanium in the pink inclusions, or to the actual removal of nitrogen from the liquid steel bath,

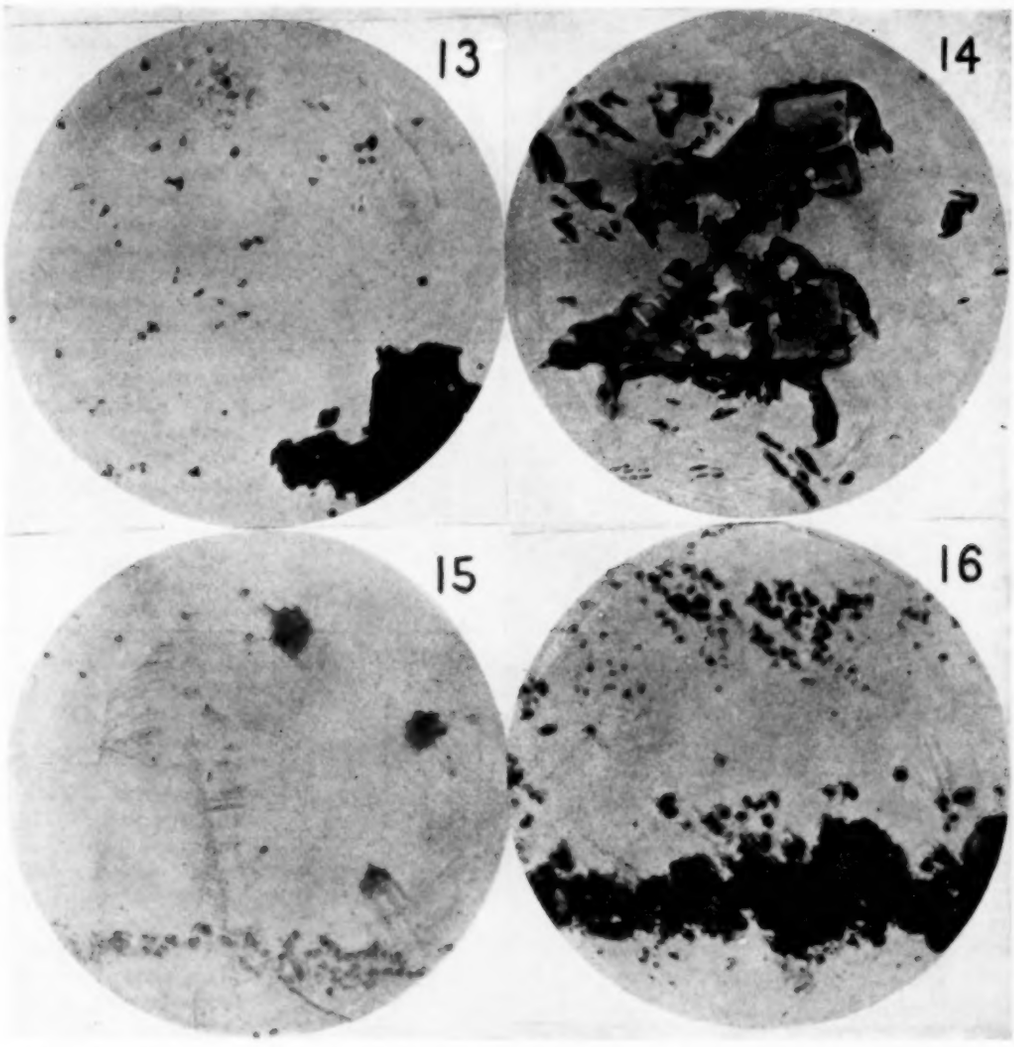

Fig. 13: Pink inclusions of titanium nitride in steel, magnified 400 diameters. Fig. 14: Crystal of pink titanium nitride in aluminothermic ferrotitanium, magnified 200 diameters. Fig. 15: Pure 5% ferrotitanium, with yellow nitride crystals, magnified 400 diameters. Fig. 16. Alumina from aluminothermic alloy in iron, dark blue in color, magnified 400 diameters.

or to both effects combined. At any rate, if it is assumed that nitrogen has an injurious effect on steel, the lower amount found by analysis must be an advantage, for even if the whole amount removed from the metal itself is still present in the pink inclusions, it could have no more ill effect in this form than any other non-metallic inclusions of the same size. As the titanium nitride inclusions are never found segregated in groups or streaks, but are always very small, scarce and thinly scattered, their weakening effect on the metal is practically negligible. It is hardly possible that the nitrogen contained in the pink inclusions could have been derived from any other source than the bath of steel to which the titanium was added, as the regular ferro carbon-titanium does not show these pink spots. Therefore their presence in a treated steel must mean that some nitrogen has been removed from solution in the metal, and this removal must be a distinct benefit, if, as some authorities claim, nitrogen is very injurious when dissolved in steel.

The fact that titanium nitride is present in certain steels must not be taken to mean that all the titanium found in them by chemical analysis is present in that form. Some of it, of course, must be, but the quantitative estimation of this compound in a given steel is a problem that has not yet been solved either chemically or otherwise. It is entirely possible that a considerable amount of titanium may be present as carbide in steels that contain the pink nitride inclusions, as well as in those that do not.

It has been found in examining a great many titanium-treated rails, that, in all except a few which contained no titanium nitride, the sulphide inclusions were smaller and more evenly distributed than in the untreated rails. This is a fact which it is hard to explain theoretically, but an interesting confirmation is shown by the steel treated with titanium sulphide (Photomicrographs 3, 5 and 6), which showed much finer sulphide inclusions than the same steel untreated.

This work is described and published with a view chiefly toward interesting metallographists and aiding them in identifying the pink titanium nitride crystals. It is believed that they have not been described before in the literature of non-metallic inclusions in steel, and a familiarity with their appearance and composition should be valuable as affording a means of knowing that steels in which they are found had been treated with titanium.

The conclusions to be drawn from the work described above are that these hard pink inclusions are composed chiefly if not entirely of titanium nitride, and that while they may also contain some carbon or iron, alumina is not necessary for their formation.

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Foot-Rule.—A four-joint two-foot rule of Starrett make is being sent by the Ashland Fire Brick Company of Ashland, Ky., to its friends on request. It is a very attractive and useful souvenir.

The probable increase in tin production in the Malay peninsula, due to the introduction of dredges and modern methods of production, is the subject of editorial comment in the *Malayan Tin & Rubber Journal*. This authority anticipates that, as the result of increased output, the price of tin will reach a lower level in the next two years. Nineteen dredges are now at work, and as many more are to be built.

Idaho's output of gold, silver, copper, lead and zinc in 1913 was valued at $24,149,049, according to the Geological Survey. The production of all metals except gold increased. The Coeur d'Alene region showed a marked increase in production of silver, lead and zinc.

The Electric Arc Furnace and the Development of the Steel Casting Industry

BY IVAR RENNERFELT

Recently a very interesting article written by Mr. G. Muntz appeared in the METALLURGICAL AND CHEMICAL ENGINEERING (June, 1914). Its object was to call attention to the special features of the converter process for making steel castings and to compare this older method with the new electric process for melting steel, which is rapidly forcing its way to the front.

It may be well worth while to investigate the correctness of several of the points brought forward in said article in favor of the converter process, as the reader, unless familiar with the modern electric arc furnace, is liable to get an erroneous idea of the relative merits of the two processes. Of course, no one will or even can deny that the small bessemer converter has assisted greatly in developing the steel foundry, but it is also undeniable that the converter has drawbacks due to its construction and to the limited range of materials for which it is adapted.

The electric furnace, on the other hand, although a comparatively new tool, has already proven itself to possess advantages which are sure to open for it a very wide field of operation. Even if we know something about electric steel melting, more remains to be discovered and invented before we have fully demonstrated its many possibilities. The first practical electric furnace for melting steel was started hardly a decade ago and it is, therefore, difficult to forecast what will be the development of the next ten years. Most of the difficulties have been overcome and rules for the design of the electric furnace have been established on the basis of a considerable practical experience with a number of different types, used for different purposes.

Economy

The first condition for economical melting of steel electrically is cheap energy. Hydroelectric power is generally the cheapest; but even medium-size steam or gas-power stations should be able to generate and sell energy at a cost sufficiently low to justify the running of a steel furnace. For the economical working of a steel foundry the continuity of operation is, however, an equally important factor at least if power is bought on the kw-year basis.

It has been found that an electrical steel foundry is well able to pay 1 cent per kw-hr. and still make a handsome profit, especially if a fair proportion of the output consists of light or difficult castings which will bring a good price per pound.

It is certainly to be expected that a well-situated and carefully managed central station can sell furnace energy at 0.5 cent per kw-hr. without losing money.

Ease of Operation

The electric arc furnace, if properly designed, is very easy to handle. It will melt any kind of iron or scrap that is put into it rapidly and without oxidation. No special haste to discharge the furnace after the heat is completed is necessary as the charge may be kept in the furnace for any length of time without any material change in its composition. As a matter of fact, the steel is really improved by remaining in the hearth for some time before pouring as slag and gases thereby are given an additional chance to rise to the surface, rendering the steel more homogeneous and solid. This method of treating a ready charge of steel would be entirely out of question in the bessemer converter or the open-hearth furnace.

Should the molding work so demand, the pouring off may, therefore, be delayed and the steel delivered as required. The converter steel, on the contrary, must be teemed as soon as possible after completion of the heat, as it is impossible to maintain for any length of time the temperature required for making good castings.

Refining Possibilities

The electric furnace is especially a refining tool by means of which the poorest kind of scrap iron may be transformed economically into the highest grade of cast steel. No other furnace can compete with the electric furnace in this respect.

The acid bessemer converter can deal only with a premelted charge of high-quality pig iron of closely limited composition, which determines the quality of scrap of high grade which may be added in the converter. In the acid open-hearth process we find the same reactions, but under better control, and with a wide range of raw materials. The basic open-hearth can deal with impure, low-grade materials and can to a certain extent reduce P and S. But neither of the above processes has as wide a range or as perfect control of the results as the electric arc furnace in which any element entering into the charge can be eliminated, practically to any extent desired.

Remelting Foundry Scrap

In every steel foundry a considerable precentage of metal melted remains in the form of risers, runners, lost castings, etc. This refined metal is very conveniently remelted in the electric furnace and constitutes a first-class raw material. The proper composition of the charge is easily controlled by adding pure ore or mill scale to reduce carbon or pig iron, coke or coal to increase it. There does not exist the slightest difficulty in controlling carbon and the opinion of Mr. Muntz on this point is decidedly not warranted by the actual facts. If properly used, the electric furnace permits a much closer control of all the elements of a charge than any other melting apparatus, not even barring the crucible in which the control of carbon, silicon and manganese is far from easy.

The use of the Tropenas or Bessemer converter is limited by the quality of the raw materials, as every one familiar with metallurgical operations knows. The pig iron must be very high grade, low in P and S and high in Si and Mn. The machinery builders are continually raising their standards and will soon not be satisfied with steel castings containing any considerable amount of the ill reputed elements S and P. The cupola melting of the pig is always liable to introduce a certain amount of S into the pig iron, as all ordinary coke holds a good deal of this dangerous element.

Smaller Loss from Oxidation

It is well known that in a well-designed and closed electric furnace a neutral or even a reducing atmosphere may be maintained.

No air enters the furnace and should any enter, when the door is opened, its oxygen will soon be consumed by the carbon of the white-hot electrodes. If the charge consists of pure steel scrap, practically no loss will take place as there is no oxidation. This is, of course, a very valuable feature, especially if the furnace is used for making alloyed steel castings from high-priced raw materials, which as a rule are very easily oxidized.

The converter is, contrary to this, known to cause a very considerable loss on account of oxidation. The raw material is twice exposed to the influence of the oxygen; first in the cupola and then in the converter. It is stated that with a small converter this loss amounts to not less than 12 to 15 per cent even with careful management. The loss may, however, under favorable con-

ditions amount to even 28 to 31 per cent (Manual of the Metallurgy of Iron, Prof. E. G. son Odelstierna, Stockholm, 1913).

This loss means not only high cost, the pig iron used being high-grade and expensive, but it also introduces an undesirable uncertainty regarding the chemical composition of the steel. The pig iron used should contain 1.5 to 2 per cent Si but not more than 0.2 to 05 Mn in order to save the lining of the converter which would suffer considerably if the charge contained more Mn. These two elements Si and Mn serve as the source of heat in the converter and are, of course, a very expensive fuel. The converter process is liable to cause a considerable amount of scrap due to the low temperature of the steel in the ladle, risers and defective castings, which has to be remelted in the cupola. If this amount is large the molten cupola metal is liable to run low in Si and Mn and may, therefore, not produce steel of the proper temperature for casting it in molds.

The electric furnace is entirely independent of what percentage of scrap is put into it and can even run on scrap only. In this case the loss by oxidation is insignificant, provided that the scrap charged is clean and free from rust.

The Supply of Raw Material

It has been supposed that a more general application of electric furnaces to foundry purposes would cause a shortage of steel scrap, raising the price of raw material to a prohibitive limit. It is, however, hardly possible that a prohibitive rise in price of scrap will be caused by the electric furnace as this is able to convert almost any kind of scrap, even such as is practically unfit for use in the open-hearth furnace which is by far the largest consumer of steel scrap. Should a rise take place, this will, therefore, more seriously affect the open-hearth steel plants and most likely a number of these plants may be replaced by bessemer converter works supplemented by electric refining and deoxidizing furnaces. Such a transformation would make large quantities of scrap available for the electric smelting furnaces at probably even lower prices than now paid by the steel works.

But the electric furnace is also suitable for the pig and ore process, receiving molten or melting a charge of pig to which is added enough ore to decarbonize the charge. For this method the consumption of energy is not prohibitive. According to tests made by the Ljusne Ironworks in Sweden it may be expected that steel can be made from pig iron and ore with a consumption of not more than 850 kw-hr. per ton, starting with a cold charge. This decarbonizing process is also suitable for removing a certain amount of phosphorus from the pig iron, thereby improving the resulting steel. The phosphorus is, of course, removed only at the end of the melting, when the percentage of carbon hase been sufficiently reduced, i.e., to 0.10 per cent or less.

If using high-grade pig iron the process may be stopped as soon as the carbon is reduced sufficiently to meet the specification for the castings. Naturally the decarbonizing can be interrupted by pouring off part of the charge at, say, 0.60 per cent C and then adding more iron ore to reduce the carbon to 0.20 per cent or less, if extra soft castings are required. This operation is performed with ease permitting the steelmaker to take all the time he wants for testing his steel in any way desired.

No "Hit or Miss" Method

The electric steel furnace makes it possible to turn out heats of steel of practically exact chemical composition. The carbon may be lowered or increased at will and additions may be made for making various kinds of alloyed steel. The quantities which in each case should be added to obtain a certain specified percentage of nickel, chromium, vanadium, etc., can be closely calculated. Sulphur and phosphorus may be reduced to practically nil if desired by simply "working" the charge with a sufficient number of refining (basic) slags, melting them one after the other, carefully removing each preceding slag before adding a new one.

The limit for this refining is only the consideration of cost. The consumption of energy and time will, of course, increase if very low-grade materials are to be converted into high-priced tool steel. The fact that a remarkable degree of refining is possible in the electric furnace is well known, quoting, for instance, Mr. E. F. Lake (*Iron Age*, March 27, 1913). In his article on "European electric steel castings" this author makes the statement that "for various reasons high-grade steel castings can not be made with the open-hearth process," and he adds "the Bessemer process need not be mentioned, as it is well known to be less adapted to such work than the open-hearth and only *applicable to very cheap castings.*" Speaking about the small converter which is a close development of the Bessemer furnace, Mr. Lake states that "this process has its limitations, however, and it is best adapted to medium grades of steel castings. The extra-fine grades require the crucible or electric furnace process for melting and refining."

The conclusion to be drawn from this is that it is certainly advisable for any steel foundry of importance to make arrangements for a suitable electric furnace in its plant. Only if this is done can the customers be assured of strictly high-grade steel, when such is required. And this is going to be frequently demanded in the future when designers and builders of machinery know that such high-grade steel castings are obtainable at short notice and at reasonable cost.

The proper course for a steel foundry would be at first to erect a furnace of medium size, say, 1 to 1½ tons capacity, to work together with the converter or whatever melting furnace may be in use. The most difficult and expensive castings could then be taken care of by the electric furnace leaving it to the converter or open-hearth to produce the lower and cheaper grades of work. This would be a natural development, greatly facilitating the more general introduction of higher grades of castings by means of this new melting tool.

Capacity of the Electric Furnace

The electric furnace when used to melt cold steel scrap is to be considered especially as a refining furnace intended more to produce quality than quantity. The time for finishing a heat depends not only on what quality of steel is wanted but also on the power available. It is possible to overload an electric furnace thereby obtaining quick melting and increased output, but if persisted in this, of course, will injure the lining of the furnace and increase the cost of maintenance. This is the case also with the converter, if it is used for a very forced work such as melting 6 tons of steel in one hour in a 2-ton converter.

Should it really be required to accumulate 4 to 6 tons of steel having available only a 2-ton electric furnace, this might be done by overheating the first and second charge considerably and pouring them in a properly designed and thoroughly preheated mixer. By properly lining the mixer it is possible to avoid loss of heat, causing the steel to cool off only very slowly.

The electric steel may therefore be kept hot for several hours without getting below the casting temperature. The steel in such a mixer may, of course, be kept hot also by means of an oil- or gasburner or by introducing a few pounds of thermit ($Al + Fe_2O_3$) which generates a very large quantity of heat, when the finely

powdered aluminium is brought to react and combine with the oxygen in the iron ore. This method, of course, involves an extra cost per ton of steel, but circumstances may justify such an occasional expense.

The Tropenas converter is always lined with acid brick. These do not stand a higher temperature than about 1650° C., the fusing point of brick being at 1700 to 1750°. Ordinary soft steel congeals at about 1450° and it is consequently not possible to overheat the steel more than 200° without spoiling the lining of the converter. The electric furnace again, if lined entirely with basic materials permits maintaining the temperature at about 2150° C. or 500° higher than is possible in the converter. The electric steel, therefore, may be poured into the basic-lined receiver at a temperature which is some 700° C. above the melting point of the steel. The electric furnace is the only one in which it is possible to produce really superheated steel of first-class quality.

Segregation

It certainly is a remarkable statement of Mr. Muntz that the electric furnace produces greater segregation than the Tropenas converter. The consensus of opinion of leading authorities is the opposite. Without doubt the electric furnace is very much effective compared to other melting tools in preventing segregation.

Mr. W. R. Walker read before the American Iron and Steel Institute, May, 1912, a paper on "the electric furnace as a possible means of producing an improved quality of steel," in which he states that ingots of even 8 tons have been produced electrically which are "practically free from segregation."

Wide Market for Electric Steel Castings

Quite contrary to the concluding statement by Mr. Muntz that the electric steel does not find a ready market is the fact that there is a wide demand for just such high-grade steel castings as can only be produced from the electric furnace. The machinery trade is constantly raising the standard specifications whenever there is the slightest chance that public safety would be endangered on account of low-grade steel being employed for important details. Builders of automobiles, locomotives, airships, elevators, carriages, street and railway cars, etc., all recognize the importance of specifying the best quality of steel obtainable at reasonable cost.

This is a well established practice in both Europe and America. The writer is in a position to testify to this, because of his connection with certain interests devoted to the economical and practical development of one of the most promising of the electric steel furnaces now in the market. The amount of inquiries for electric furnaces coming in from all parts of the world, and especially from the United States, is astonishing and is a sure indication of the future electric steel melting. People are beginning to realize that the electric furnace has come to stay, but that it is by no means "foolproof." It is quite possible to spoil steel in several ways and it must not be expected that any person not familiar with steel generally should be able to use the electric furnace to best advantage. If, however, the quality of the steel in any charge is not satisfactory, it is in most cases possible to correct this by making proper additions to the bath, keeping it long enough to obtain exactly the steel which is wanted.

If handled with reasonable care and intelligence the electric furnace is really a most useful and easily managed melting apparatus, certain to play an important role in the future development not only of the steel casting industry but in the whole art of iron and steel making.

Aktiebolaget Elektriska Ugnar,
Stockholm, Sweden.

Goslar Convention of the Association of German Metallurgists

The annual meeting of the Association of German (non-ferrous) Metallurgists and Mining Men (Gesellschaft Deutscher Metallhütten- und Bergleute) was held from July 3 to 6, 1914, in Goslar in the Hartz Mountains.

After various visits to mines and metallurgical plants in the neighborhood the meeting was opened on the evening of Friday, July 3, by a speech of the president of the association, Mine Director **Niedner**, of Tarnowitz, in Upper Silesia.

Bergrat **Wolff** then lectured on some of the geological and technical problems of the Rammelsberg mine.

On Saturday, July 4, various other industrial plants were visited and an excursion was made to Hartzburg. In the evening a social meeting was held at which two American engineers, **H. N. Stronck** and **J. F. Boyle**, lectured on scientific management in mining and metallurgy. The subject of their discussion was the problem how with higher wages it is possible to reduce the cost of operation in mining and metallurgy on the basis of the principles of scientific management.

The business meeting was held on Sunday, July 5. Bergrat **Volgelsang**, of Eisleben, was in the chair. The membership is now more than 800. The organ of the society is the journal *"Metall und Erz."* A special section has been formed for zinc metallurgy, and at the first meeting of this section Director **Holey**, of Duisburg, had lectured on the roasting of zinc blende.

Papers were then presented by Professor **Krusch** on possible platinum deposits in Germany and by Director **Juretzka**, of Breslau, on the metallurgy of zinc. The author pointed out that on account of the rise of the price of lead and zinc various new processes have been introduced into practice. He discussed recent improvements in the manufacture of retorts and in the drying of the retorts and gave the results of experiments on the winning of zinc in vertical retorts. He also discussed the problem of zinc smelting in shaft furnaces.

Finally Mr. **Bueler de Florin**, of Aussig, read a paper on the use of nitric acid for the leaching of ores, giving a review of various processes which have been proposed in this field. Kingsley and Rankin have proposed to let nitric acid react with sulphide ores, especially lead sulphide. Kingsley intends to produce a lead nitride solution. Rankin intends the formation of lead sulphate which is possible with the use of concentrated acid at a raised temperature with stirring and the application of two atmospheres pressure. The Norsk Hydro-Elektrisk Kvaelstoffaktieselskab has proposed a treatment of ores containing bismuth as sulphide or oxide in small quantities. The author has proposed leaching copper oxide or carbonate ores rich in lime and free from sulphur with diluted nitric acid.

In all four processes the regeneration of the acid forms an important step. How this is carried out in the four processes is shown in the following equations:

Kingsley:

Treatment of ore:

$$3PbS + 8HNO_3 = 3Pb(NO_3)_2 + 2NO + 4H_2O + 3S$$

Regeneration of acid:

$$Pb(NO_3)_2 + Na_2CO_3 = PbCO_3 + 2NaNO_3$$

$$2NaNO_3 + H_2SO_4 = Na_2SO_4 + 2HNO_3$$

Rankin:

Treatment of ore:

$$3PbS + 8HNO_3 = 3PbSO_4 + 8NO + 4H_2O$$

Regeneration of acid:

$$2NO + 3O + H_2O = 2HNO_3$$

Norsk Hydro-Elektrisk Kvaelstoffaktieselbskab:

Treatment of ore:

$$Bi_2O_3 + 6HNO_3 = 2Bi(NO_3)_3 + 2H_2O$$

Regeneration of acid:

$$Bi(NO_3)_3 + H_2O = BiONO_3 + 2HNO_3$$

Bueler:

Treatment of ore:

$$CuCO_3 + 2HNO_3 = Cu(NO_3)_2 + H_2O + CO_2$$

Regeneration of acid:

$$Cu(NO_3)_2 = CuO + N_2O_5$$
$$N_2O_5 + H_2O = 2HNO_3$$

The treatment of ores with nitric acid is, however, sensible only if the nature of the ores or the local conditions exclude the use of other methods. After the close of the meeting a banquet was held and on Monday, July 6, a visit was paid to the Rammelsberg mine.

Some Economic Aspects of Industrial Chemistry*

BY DR. BERNARD C. HESSE

In considering this subject the difficulty lies not in a scarcity of material, but principally in keeping the discussion of the voluminous matter within a small compass.

Taking the thirteenth census of the United States as a guide in ascertaining what is regarded by the Census as industrial chemistry, it will be found that in the division of chemical and allied products, metals and all metallurgical operations are excluded, as well as the production of refined petroleum, and a host of other large industries such as glass, soap, pottery, sugar, starch and the fermentation industries which depend upon chemical reactions and chemical control for their successful execution.

The Census of the United States includes under chemicals and allied products nine principal divisions:

1—Paint and varnish.
2—Chemicals.
3—Fertilizers.
4—Explosives.
5—Dyestuffs and extracts.
6—Sulfuric, nitric and mixed acids.
7—Wood distillation (not including rosin and turpentine).
8—Essential oils.
9—Bone, carbon and lampblack.

For the present, these nine divisions of the Census will be considered. Having arrived at a tentative conclusion as to the scope of the subject matter, this subject matter will be considered from the two following aspects:

I—The relationship of these industries to the manufacturing industry of the United States as a whole.

II—The position of the United States in those respects as a buying and selling nation.

The volume and distribution of foreign trade of the United States in the fiscal year of 1913 is given by the Department of Commerce as follows:

Exports	$2,428,506,358
Imports	1,812,978,234
Total	4,241,484,592
Excess of exports	615,528,124

In order to obtain a conception of the relationship of these nine branches of chemical industry to the manufacturing industries of the United States as a whole, Table I will be helpful.

The story told by Column D is encouraging in some respects, and is not so encouraging in others. Compared with other manufacturing industries, the chemical and allied industries do not so easily lend themselves to small units. It takes 3.3 times as much capital for the average chemical plant as for the average manufacturing plant. This is the discouraging feature from the individual point of view.

*Lecture delivered at the College of the City of New York on May 1, 1914. Slightly abstracted.

From the broader point of view, Column D, however, is very encouraging. The average chemical plant requires 50 per cent. more help than the average manufacturing plant; it employs over two and a half times as many salaried employees as does the average manufacturing plant, but unfortunately only 34 per cent. more than the average number of wage-earners. The average chemical plant bears much more than its proportionate share of expenses, whether in the shape of salaries, wages, materials, or miscellaneous expenditures; in the value of the product produced per unit of chemical plant the average chemical plant produces 161 per cent. more than its average share.

If the principal object of manufacture be the enhancement of value of the outgoing material over the incoming material, then the fact that the average chemical plant enhances its raw material 148 per cent. more than its average share is a matter for congratulation and of encouragement.

Turning now to the question of productive power of capital invested in chemical industry, it will be found on inspecting Column E that a dollar is not so productive in the chemical and allied industries, average against average, as in the other branches of manufacturing endeavor. The disbursements for salaries, materials, power, value of product and expenses of miscellaneous nature are each about three-quarters of the average of the same items for the other branches of manufacture, and the enhancement in value is only 75 per cent. of the average enhancement produced by unit capital investment in the other branches of manufacture. The dollar so invested employs fewer wage earners, salaried or otherwise, than a dollar otherwise invested in manufacturing enterprise. This, of course, is merely a natural consequence of the high initial cost of plant, the large size unit of plant required and the close markets.

Turning to the value of products in Column B, it is to be noted that the percentage participation of each of the nine divisions in that title is as follows:

Paint and varnish	29.4	Sulfuric, nitric and mixed acids	2.3
Chemicals	27.4	Wood distillation	2.3
Fertilizers	24.5	Essential oils	0.3
Explosives	9.4	Bone, carbon and lampblack	0.4
Dyestuffs and extracts	3.8		

The thirteenth census of the United States has distributed the participation of these nine divisions in this amount of product with considerable detail, which does not lend itself very well to discussion. The not specifically described items amount to $73,563,059, or 17 per cent. of the total. For the purpose of obtaining a better understanding of the relationship of the various principal items under each of these nine divisions, Table II has been prepared.

Within the nine divisions given, the United States is in a large measure self-sustaining, although it is necessary for it to obtain much of the raw material from abroad. In the division of dyestuffs and extracts, and particularly that portion of it dealing with artificial dyestuffs, it is to be noted that during 1913, the total importation into the United States of artificial dyestuffs, exclusive of alizarine dyes and indigo, amounted to $7,105.284; during the census year of 1910 this country manufactured $3,462,436 worth of such artificial dyestuffs which amounts roughly to 32 per cent. of this country's entire consumption of the so-called coal-tar dyes; no doubt, since the census year 1910, the domestic production of coal-tar dyes has increased. However, much of the coal-tar raw material used in such manufacture comes to us from abroad, particularly from Germany and England.

In the fertilizer division we are, of course, dependent for our potash requirements, upon Germany, and these

TABLE I.

COMPARISON OF CHEMICAL AND GENERAL MANUFACTURING IN CONTINENTAL U. S.

	Items	Manufacturing establishments A Total	B allied products	C Percentage of A in B	D(a) Ratio of Aver. chem. plant to Av. general manuf. plant	E(b) Average in chemical plants for $1 investment
1	Number of establishments	268,491	2,140	0.79	....	0.30
2	Persons engaged in manufactures	7,678,578	88,097	1.15	1.44	0.44
3	Proprietors and firm members	273,265	1,155	0.42	0.53	0.16
4	Salaried employees	790,267	16,516	2.09	2.64	0.80
5	Wage earners (average No.)	6,615,046	70,426	1.06	1.34	0.40
6	Primary horsepower	18,680,776	398,880	2.14	2.71	0.82
7	Capital	$18,428,270,000	$483,729,410	2.62	3.31	....
8	Expenses	18,453,080,000	359,425,126	1.95	2.46	0.74
9	Services	4,365,613,000	62,700,767	1.44	1.82	0.55
10	Salaries	938,575,000	24,042,566	2.56	3.24	0.98
11	Wages	3,427,038,000	38,658,201	1.13	1.43	0.43
12	Materials	12,141,791,000	258,115,975	2.13	2.69	0.81
13	Miscellaneous	1,945,676,000	38,608,384	1.98	2.51	0.76
14	Value of products	20,672,052,000	425,084,540	2.06	2.61	0.79
15	Value added by manufacture (value of products less cost of materials)	8,530,261,000	166,968,565	1.96	2.48	0.75

(a) Values obtained by dividing separate items in C by Item 1 in C. (b) Values obtained by dividing separate items in C by Item 7 in C.

TABLE II.

ANALYSIS OF CHEMICAL AND ALLIED PRODUCTS BY DIVISIONS.

PAINT AND VARNISH INDUSTRY.	Value in Dollars	Percentage of Total Division
Pigments	16,985,588	13.6
Paints in oil	56,763,296	45.4
Varnishes and Japans	31,262,535	25.0
Fillers	3,126,271	2.5
Water paints and kalsomine	1,979,007	1.6
Linseed oil	1,912,594	1.5
Bleached shellac	578,650	0.5
All other products	12,281,481	9.8
Total	124,889,422	
CHEMICALS		
Acids	11,926,389	10.1
Sodas	21,417,982	18.1
Potashes	88,940	0.7
Alums	2,578,842	2.2
Coal tar products	2,675,327	2.3
Cyanides	1,941,893	1.6
Bleaching material	1,635,046	1.4
Chemical products made by the aid of electricity	17,968,277	15.2
Plastics	7,180,172	6.1
Compressed and liquefied gases	4,969,805	4.2
Fine chemicals	10,956,666	9.3
Chemicals not elsewhere specified	34,349,548	29.1
Total	117,688,422	
FERTILIZERS		
Fertilizers	92,369,631	88.8
Superphosphates	13,318,529	(12.8)
Ammoniated fertilizers	10,061,193	(9.7)
Concentrated phosphate fertilizers	3,638,210	(3.5)
Complete fertilizers	57,243,899	(55.0)
Other fertilizers	8,107,800	(7.8)
Sulfuric acid for sale (as 50° Bé. acid)	923,492	0.9
Other acids for sale	611,288	0.6
All other products	10,055,802	9.7
Total	103,960,213	
EXPLOSIVES		
Dynamite	18,699,746	46.6
Permissible explosives	863,209	2.2
Nitroglycerin	3,162,434	7.9
Blasting powder	9,608,265	24.9
Gunpowder	1,736,427	4.3
Other explosives	3,913,787	9.7
Materials not elsewhere specified	2,155,793	5.4
Total	40,139,661	

DYESTUFFS AND EXTRACTS	Value in Dollars	Percentage of Total Division
Artificial dyestuffs	3,462,436	21.6
Extracts for dyeing	991,974	6.2
Extracts for tanning	6,449,105	40.4
Other tanning materials	625,401	4.0
Mordants	99,797	0.6
Sizes and finishes	2,418,652	15.0
Ground and chipped woods, etc.	344,761	2.2
All other products	1,562,448	9.7
Total	15,954,574	
SULFURIC, NITRIC AND MIXED ACIDS		
Sulphuric acid	5,629,496	57.0
Nitric acid	499,303	5.1
Mixed acid	1,438,475	14.6
All other products	2,316,783	23.5
Total	9,884,057	
WOOD DISTILLATION (not including rosin and turpentine)		
Wood alcohol:		
Crude	1,627,878	16.7
Refined	2,901,709	29.8
Acetate of lime	1,981,220	20.3
Charcoal	2,351,644	24.0
Turpentine	249,526	2.6
All other wood distillation products	357,290	3.7
All other products	267,731	2.8
Total	9,736,998	
BONE, CARBON AND LAMPBLACK		
Bone black	1,070,333	50.0
Carbon black	625,514	29.3
Lampblack	439,707	20.6
Total	2,135,554	
ESSENTIAL OILS		
Oil, peppermint	519,079	29.8
Oil, black birch	102,045	5.9
Oil, spearmint	83,283	4.8
Oil, wintergreen	68,983	3.9
Other oils	335,213	19.3
Witch-hazel extract	412,322	23.7
All other products	216,309	12.4
Total	1,737,234	

amount in round numbers to $1,000,000 per month. In the same division we are dependent upon Europe for much of the ammonia entering into the fertilizers, amounting in 1910 to over $4,000,000. It will probably not be long before most of our ammonia requirement is supplied by our own by-product coke-ovens.

Industrial Chemistry in Its Broad Aspect

However, industrial chemistry or chemical industry is much broader in scope than is indicated in the thirteenth Census of the United States on chemicals and allied products. From the point of view of the person with chemical training, every industrial operation which calls for chemical control is a branch of industrial chemistry or of chemical industry, the two terms being used interchangeably.

In Germany the official classification of material connected with chemical industry is as follows: 1—Malt, oil, fruits, plants, etc. 2—Industrial or medicinal vegetable products. 3—Tanning extracts. 4—Resins, gums and adhesives. 5—Caoutchouc and camphor. 6—Animal and vegetable fats and oils. 7—Animal products. 8—Starch and sugar. 9—Alcohol, acetic acid, mineral waters. 10—Mineral and fossil raw materials. 11—Ores, iron and slags. 12—Fossil fuels. 13—Mineral oils and like fossil raw materials. 14—Coal-tar oils and products. 15—Waxes. 16—Soap and fat products. 17—Chemical and pharmaceutical products. 18—Miscellaneous chemical and pharmaceutical products. 19—Dyes and dye materials. 20—Ethers and alcohols. 21—Volatile oils, synthetic perfumes, toilet articles. 22—Artificial fertilizers. 23—Explosives and combustibles. 24—Wood fiber and chemical paper. 25—Metals.

These twenty-five large classes or divisions comprise four hundred and forty-two sub-classes.

An examination of the records of imports and exports into and from the United States during the fiscal year 1913, discloses a total business of $4,241,484,592; of this, not less than $1,302,274,994 or 30 per cent. deal with products of chemical industry or materials used in the

products of chemical industry, and of these $759,193,688, or 18 per cent. of the total represents imports and $543,081,306, or 12 per cent. of the total represents exports leaving a balance of trade against the United States, $216,112,382.

LARGE ITEMS IN CHEMICAL TRADE OF THE U. S. FOR 1913.

IMPORTS	
Sugar	$204,212,581
Hides and skins	117,386,174
Unmanufactured India rubber	101,333,158
Paper and paperstock	27,706,697
Potash compounds	14,408,124
	$465,046,734
EXPORTS	
Refined petroleum and its products	$139,882,905
Copper as metal	120,605,914
Beef and hog products	82,890,777
Leather	42,384,199
Naval stores	26,471,492
Fertilizer material	11,400,888
Cement industry	5,822,107
	$429,458,282

Information as to the distribution of the exports and imports just given as to countries of destination and countries of origin is not readily assessible, since it would be a never ending task for the officials of the Department of Commerce to rearrange all of this vast information from the various points of view possible.

Movement of Chemical Products Between Germany and the United States

However, fragmentary information is accessible with respect to the relationship between the United States and Germany as regards the interchange of chemical products between the two countries. This information is based upon German official publications.

From the point of view of values, information is at hand for only the year 1904. In that year Germany sent to the United States $16,993,200 worth, and the United States sent to Germany during that time $38,194,240, or an excess in favor of the United States of $21,201,040, which means about $1,800,000 per month.

With regard to the tonnage movement between those two countries, information for the year 1913 is at hand, and it shows that during that period a total of 3,430,564 metric tons of commodities of the chemical industry passed between the two countries, of which 1,917,430 metric tons passed from the United States to Germany, and 1,513,134 metric tons passed from Germany into the United States; that is, the United States sent to Germany an excess of 404,000 tons over what it took from Germany in 1913.

Freight Movements in the United States

In 1911 the total freight movement over the railroads of the United States amounted to 967,233,991 tons; of these about 14 per cent. comprised manufactured goods, and about 28,000,000 tons of the total freight moved was composed of products of chemical industry, that is, about 3 per cent of the total freight movement of this country is represented by products of chemical industry. The three and a half million tons gross above referred to between the United States and Germany, therefore, represent about 12 per cent. of the probable total freight movement of products of chemical industry in this country.

Efficiency of American Industrial Chemistry

An examination of the relative exports and imports of products of chemical industry from and into the United States shows that there is little, if any, ground for criticism of American chemists in not utilizing their opportunities. It is safe to say that the American chemical industry is developing its own natural resources with a degree of foresight and success very favorably comparable with that accomplished by chemists in other lands. Much is heard in criticism of American chemists for not developing a coal-tar chemical industry, but I do not believe such criticism to warrant a wholesale belief in the backwardness of American chemists. There can be no question that the chemical work involved as well as the engineering work involved in the production of a useful and usable illuminating oil, or a medicinal preparation from crude petroleum, compares very favorably with the chemistry involved and the engineering involved, in the production of the majority of so-called coal-tar dyes. The relative economic value of the two products is, of course, in favor of the products of petroleum.

It will be sufficient to say Germany is supreme in the coal-tar dye industry, because (1) Germany was the home of the industry; (2) the industry itself is so dependent upon interlocking chemicals and the growth of this interlocking dependence has been as fast as economic development warrants and has now reached such a stage of complexity and interdependence that it is difficult of transplantation as a whole; (3) there are relatively few so-called staple articles among the coal-tar dyes—by staple is meant those which are consumed in quantities to be measured by tons—many of those few are so interlocked with subsidiary or by-products that the transplantation of the work out of Germany would be economically unprofitable.

Wherever it has been profitably transplantable to this country, the manufacturing of such staples has been done, and with considerable success even though the raw material supply is still provided by Europe.

Theory and Practice

The chemical industry, probably more than any other industry, is dependent upon the application of much theoretical work, i. e., scientific work to every-day conditions, and in order that the chemical industry may grow, it is necessary that there should be brought to bear upon the manufacture of each and all of the products the highest chemical training available under the circumstances. The beneficial interaction of practice upon theory and theory upon practice, is evident in almost every branch of industrial chemistry. It has been brought to its highest efficiency, however, in the organic division and more particularly that dealing with coal-tar dyes and synthetic medicinals and pharmaceuticals. However, the chemist can, with profit follow Mr. Kerr's excellent advice to engineers when a difficulty is encountered: "Go as far as you can see and then see how far you can go."

The simplification brought about in organic chemistry through the creation of the Kekulé conception of the structure of benzol, made the development of the coal-tar dye industry in its early stages possible, or at any rate immeasurably facilitated it. In return, the coal-tar dye industry has enriched scientific or theoretical organic chemistry with a wealth of information and facts with respect, not only to benzol, but to naphthalene, anthracene and the higher aromatic hydrocarbons; the two working together have developed a very large number of new classes of organic compounds, for example: the azines, oxazines, numerous classes of azo compounds and the wealth of oxy and oxyamido derivatives in all the classes. New methods of sulfonation, chlorination and nitration have been developed almost without number, and in turn, theoretical organic chemistry has supplied the industry with many useful methods of the same kind.

To contemplate the results of this interaction is to view one of the greatest of intellectual triumphs. It is this very fact that has misled so many to ascribe to the coal-tar dye industry an economic effect far beyond its actual and to belittle the economic effect of the so-called inorganic industry. It is perfectly safe to say that the

money value of the inorganic exceeds the money value of the dye industry by at least 15 to 1.

From 1877 down to the close of 1912 there were taken out in Germany 5,675 German patents, or 158 per year, dealing with the utilization of coal-tar hydrocarbons and their by-products; it has been estimated that not more than one out of every hundred has secured financial returns for its owners. During the years 1895 to 1903, 382 German patents, or at the rate of 48 per year, were taken out in the inorganic chemical industries.

It would be an interesting subject for speculation to consider the intellectual effort involved in the 5,675 coal-tar patents as compared with the intellectual effort required for the 382 inorganic patents. It would also be of interest to consider the difficulties, financial and otherwise, in the way of creating those respective patents. A far-reaching experiment can be made in the coal-tar industry for a very little expenditure of material and labor, but in the inorganic industry the expenditure of material and labor is inordinately greater. You can make a coal-tar dyestuff and determine whether there are any probabilities of its having commercial utility at an infinitely slighter expense than you can determine whether certain alterations in the construction of a bleach-chamber in the production of bleaching powder will or will not be profitable; on the other hand, as you approach the more highly developed and almost completed manufacturing phase of coal-tar dye chemistry, you immediately come into about the same difficulties and embarrassments that you do in the inorganic field, and for precisely the same reason, namely, that in both cases you are endeavoring to develop refinements, and refinements are much more difficult of detection, elaboration and application than is the question of determining whether you have, or have not, a new and probably useful dyestuff.

By way of illustration, there are probably fewer than 35,000 compounds listed in Beilstein, but it will be no difficulty whatever to find a dozen different patents on coal-tar dyes, each and every one of which covers several million, even several hundreds of millions of different and distinct dyestuffs. Of course, to discover a new type of a dyestuff is almost as difficult as it is to discover a refinement in the almost fully developed inorganic industry, but once the type is given, there is no difficulty in creating a new dyestuff under that type.

The Function of the Chemist as an Individual

Now, the function of the chemist in the production of things is twofold. Take the apparently most humble position, namely, that of analyst. Upon his accuracy of manipulation depends, in a large measure, the profitableness of the undertaking. If an analyst makes a mistake of 1 per cent. in determining copper, on the $120,000,000 worth that we export annually, that would mean a loss of $100,000 per month. Therefore, analytical control, in order to be of value, must be accurate, since inaccuracies can easily run into large sums of money.

But the chemist's contribution does not stop merely with control; he does create a great many new uses for old things, and he does create new things and find uses for them. To be able to do these things to the best advantage, he must be thoroughly versed in what has been done, must know what tools are at his command, must be able to use those tools and to tell when they shall be used, must possess also the merchant's instinct of values, if he desires to rise to the highest efficiency in industrial chemistry. Of course, he must know how to handle men, and how to get results with what is at his command, as must anyone who attempts to conduct any business enterprise.

He must be alert, and he must overcome any disdain that he may naturally have for small things, for in industrial chemistry, perhaps oftener than in any other, it is the small thing that has pointed the way to achievement and success.

It is an old story how the production of benzol from coal gas was brought about by a mistaken notion that oxalic acid could be made from coal gas and nitric acid. An alert and very observant chemist in repeating this attempted synthesis found not only that oxalic acid was not formed, but that nitrobenzol was produced with benzol dissolved therein. That was the beginning of the recovery of benzol from coal gas, and the addition to the sources of benzol of a source much greater and more dependable than any theretofore available.

The neglect of a laboratory boy to maintain the temperature he was directed to keep in a certain vessel, taught that laboratory boy nothing, but the chemist in charge following up this result, finally ended up with a method of substituting sulfuric acid for bromine, thereby reducing the cost of production by over 50 per cent. In both of these cases it is very doubtful if a man having no training beyond that required in the production of the things with which he was directly concerned, would ever have made those discoveries. The attempt to make oxalic acid would have resulted in failure, and would have been so reported, the result of the laboratory boy's negligence would have been dumped into the sewer, and a new start made along the original lines.

Conclusion

I have shown how, in a national sense, the chemical industry contributes a very substantial portion to our national welfare and the useful part it plays in this work-a-day world, in the employment of persons, materials and of capital; how in a broader sense it touches almost every field of human activity; how it is interwoven with the means required for the gratification of all our personal needs and desires.

It needs merely to be mentioned in order to bring about a full appreciation of the importance of the chemical industry to refer to the important part it plays with respect to agricultural chemistry. The chemical methods of investigation and research applied to agricultural problems indicate the requirement of certain materials by the soil, and these materials are supplied by the chemical industry. In that way the chemical industry contributes to the activity of the soil and the increased output per unit area of agricultural products.

Conversely, as in the case of alizarin and indigo, hundreds upon hundreds of square miles of the earth's surface were devoted to the cultivation of the plants necessary to produce these articles. This very large area is no longer required for that purpose, and it is safe to say that in the chemical factories now producing these things the combined working area is under four square miles. Right or wrong, I have always personally felt that had the botanist devoted the necessary attention to the growth and cultivation of indigo plant when the first synthesis of indigo was announced in 1880, the displacement of vegetable indigo between 1897 and 1900 by synthetic indigo would not have taken place, or at any rate, it would not have been accomplished after so brief a struggle. The botanist has assisted wonderfully in increasing the alkaloidal content of cinchona barks, and in the discovery of a large number of new plants capable of producing a latex suitable for India rubber production and he has also contributed greatly to the development of plantations, wherein the yield per unit area is much increased.

While at the present day it may not be commercially profitable to produce synthetic rubber, or synthetic camphor, or synthetic nitric acid, or synthetic ammonia, yet

it is perfectly true that the very existence of these possible synthetic sources of these materials renders it less and less likely that there will be any undue advance in the cost to the consumer of these articles; at any rate, the cost will not be advanced beyond a figure where the synthetic process can achieve a reasonable profit.

Chemical industry, therefore, not only provides for our present needs, but acts as safety device against famine, shortage or undue monopolization of a number of vegetable and mineral products.

Features in Work of Bureau of Standards

Secretary of Commerce Redfield has just received a report from the director of the Bureau of Standards relative to the work of that bureau which shows how many interesting features there are in the varied and extensive work of testing and investigation being conducted by that bureau.

For some time the bureau has been working on *safety rules* to be observed in the operation and maintenance of electric generating stations and substations, and on the overhead and underground distributing wires in connection therewith, and a set of rules has been prepared for publication by the bureau.

The report on mitigation of *electrolysis damage* in Elyria, Ohio, has beeen completed and was presented to the city, the gas company, the telephone company and the railway company some weeks ago and accepted by all the interests involved. The railway company has promised to do everything recommended by the bureau, which will result not only in correcting very serious electrolysis troubles but also will improve the street-railway service in Elyria and vicinity, improve the lighting of the cars and save enough money to the railway company to justify fully the total expense involved apart from the consideration of electrolysis mitigation. This is to be accomplished by a rearrangement of their distribution system and the installation of negative cables for the return of street railway current to the power stations. Because of these economies the railway company is willing to undertake the expense of new construction and new arrangement without recourse to city ordinances or pressure from the courts.

In the *cement laboratory* in Washington tests were made from samples for delivery of about six thousand barrels. At the Northampton laboratory the June shipments sampled and tested represented 66,700 barrels of cement, an average daily rate of 2565. It is interesting to note in this connection that the total shipments tested at this laboratory now aggregate 6,158,108 barrels, mainly for the Panama Canal.

About two months ago an instrument was constructed for the United States Weather Bureau for measuring the so-called *nocturnal radiation*, which usually is a loss of heat from terrestrial substances into space. The latest report shows that this instrument is unusually sensitive and that it meets all the requirements.

The influence of atmospheric conditions on the *testing of sugars* has long been an unknown quantity owing to the difficulty of controlling both temperature and humidity in the research laboratory. Relatively large and inexplicable differences have been noted for some years between the tests on imported sugars for the collection of duty at the various ports of entry. So great have been these differeces that sugars have purposely been imported via certain ports with the intent of paying a lower rate of duty. The bureau has studied this question, and its investigation now shows not only the exact cause of differences but also a simple and certain method of eliminating them.

One of the interesting and important pieces of work has been the establishment of a *standard of radiation* of which not merely the light in a visible spectrum was measured but the total radiation visible and invisible was accurately determined. These determinations have been completed with four radiometers and show most excellent agreement as to results, within 0.5 per cent compared with the previous calibration of these lamps. Hence the standard of radiation as defined by these laamps may be considered well established. This standard is quite distinct from standards of light.

Program of Chicago Meeting of the American Institute of Metals

The eighth annual meeting of the American Institute of Metals will be held in Chicago from Sept. 7 to 11 (Monday to Friday).

Monday, Sept. 7: Registration La Salle Hotel.

Tuesday, Sept. 8, 10 a. m.: Joint meeting with the American Foundrymen's Association, Hotel La Salle. Subject: "Safety Work."

Safety and Foundry operations, address by M. W. Alexander, General Electric Company, West Lynn, Mass.
Safety First, by F. W. Reidenbach.
Progress in the Safety First Movement, by Arthur T. Morey.
Safety in Connection with Grinding Wheel Operations, R. G. Williams.
Safety in Sanitation, by A. W. Gregg.
Safety First—Driving Back the Saloon, by Thomas D. West.

Tuesday, 2 p. m., Hotel La Salle: General papers and reports.

Report of Official Chemist, by Arthur D. Little, Inc.
Progress in the Nomenclature of Alloys, by G. K. Burgess.
Some Recent Applications of Metallic Cobalt, D. B. Browne.
Drop Pouring Process of Casting, by E. A. Barnes.
Bull Run Tale, by Jesse L. Jones.
Modern Die-Casting Practice, by Charles Pack.
Die Cast Aluminum, by A. B. Norton.
Non-ferrous Alloys for Automobile Construction, E. B. Horne.

Wednesday, Sept. 9, 10 a. m.: Saddle and Sirloin Club, Stock Yards. Cost Congress. Joint session with A. F. A.

Foundry Cost Keeping, by F. J. Stevenson.
Efficiency in Foundry Operations, the Essential Factor in Reducing Production Costs, by A. K. Hathaway.
Efficiency in Foundry Work, by F. A. Parkhurst.
Revision of the A. F. A. Standard Foundry Cost System, by Harrington Emerson.
Practice in Estimating Selling Price of Castings, by A. O. Backert.

Wednesday, 2 p. m.: Rolling Mills; Physical and Chemical Testing.

Care and Conversion of Rolling Mill Scrap, by W. W. Rogers.
A Brief Visit to a Rolling Mill, by Edward J. Gutsche.
A Hot Shortness Testing Machine for Aluminium Alloys, by A. B. Norton.
Making Aluminium Test-Specimens on Castings, by A. B. Norton.
Standard Test Bars of the Zinc and Bronze, Copper 88, Tin 10, Zinc 2, by C. P. Karr.
A New Method for the Determination of Zinc in Alloys, by G. E. Lundell and Mai Kim Bee.
Brinnell Hardness Testing of Non-Ferrous Alloys, V. Skillman.

Thursday, Sept. 10, 10 a. m.: Saddle and Sirloin Club, Metallurgy and Metallograph.

Commercial Classification of Copper, by Lawrence Addicks.
Spelter Manufacture and Properties, by George C. Stone.
Metallurgy of Tin and Antimony, by W. A. Cowan.
Ternary Alloys of Copper, Tin and Zinc, by S. L. Hoyt.
The Effect of Repeated Remelting on Copper, by F. O. Clements.

Thursday, 2 p. m.: Melting Practice.

Tests of Electric Furnaces for Brass Foundry, Herbert G. Dorsey.
Electric Furnace for Medium Temperatures, by E. M. Schmelze.
Electric Brass Melting from the Central Station Viewpoint, by H. M. St. John.

Friday, Sept. 11, 10 a. m.: Saddle and Sirloin Club.

Melting Losses in Electric Brass Furnaces, by H. W. Gillett and J. M. Lohr.
Use of Producer Gas in Melting Yellow Brass, by E. B. Guenther.
Test of Natural Gas Fired Furnaces under Factory Conditions, by Fred L. Wolf and Robert B. Burr.
Electric Brass Melting, by G. H. Clamer and Carl Hering.
Pyrometers for Melting Brass and Bronze, by H. W. Gillett.

Utah Meeting of American Institute of Mining Engineers

The Utah meeting of the American Institute of Mining Engineers proved after all a tremendous success, featured by cordial hospitality, elaborate entertainment, and excellent technical sessions, in which metallurgical papers predominated. Owing to the somewhat unsettled conditions of the Western mining field, there had been a doubt whether it would not be better to postpone the meeting, and recommendations to that effect had been made by Utah and Colorado members. But cooler council fortunately prevailed and the meeting was held exactly according to the program in almost every point. The only notable omission was the trip on Tuesday to the Arthur concentrating mill, which had been closed down.

The attendance was large and high-class. The registration list showed 340 names.

After an organ recital at the Mormon Tabernacle in the afternoon of Monday, Aug. 10, and an automobile trip through Salt Lake City, the meeting was officially opened on Monday night in the ballroom of the Hotel Utah by President B. B. THAYER.

D. C. JACKLING welcomed the society to Salt Lake City and reviewed the mining and metallurgical developments in Utah and the contributions of Utah engineers to progress in the industry.

The subject of the technical session which followed and in which R. C. GEMMEL presided was a symposium on copper leaching, papers being presented by Messrs. Laist and Aldrich, Laist and Frick, Austin, Croasdale, Laist and Wiggin, Holt.

Copper Leaching

Leaching at Anaconda

The paper by **Frederick Laist** and **Harold W. Aldrich** discusses "Experimental Leaching at Anaconda." The object of the construction and operation of the 80-ton leaching plant was to test out the leaching of sand tailings on a large scale and, if possible, determine a definite method of operation, and the best construction for the larger unit which is now being built. It was also of importance to obtain some practical data as regards cost items.

The 80-ton plant was not expected to be a commercial success. A leaching process on such low-grade material necessitates the treatment of a very large tonnage. Such a cost item as labor, for instance, is entirely out of proportion in such a small plant. The amounts of acid, salt, scrap iron, and fuel for roasting, however, are the same per ton in an 80-ton plant as in a 2000-ton plant. These costs were definitely established. Also the percentages of extraction and grade of tailings were definitely determined for a large-sized unit.

The equipment of the plant and the gradual changes which were made in equipment and method of operation are described in great detail in the paper. Originally the six-hearth MacDougall roaster was designed for oxychloride roasting and salt was added on the fourth floor. After a 50-day successful run it was decided to discontinue the feeding of salt into the furnace and see what results could be obtained. This method offered many advantages. No valuable metals were volatilized and no accretions formed in the furnace to cause trouble. The extraction on the copper was even better than on the chloridizing roast, but the silver recovery was not so good.

For the detailed results of the tests the reader must be referred to the complete paper (*Bulletin* Amer. Inst. Min. Eng., August, 1914, p. 2165). It must suffice here to give the chief general results:

The feed from the mill averages between 0.65 and 0.70 per cent. copper, about 5 per cent. moisture, and about 3 per cent. sulphur. Ninety tons per 24 hr. of this feed can be roasted in a 20-ft. MacDougall furnace of the type used with a coal consumption of 2.75 per cent. of its dry weight. The calcine will contain about 0.6 per cent. sulphur. About 40 per cent. of the copper is water-soluble.

It requires about 20 per cent. of the weight of the calcine in weight of solution to saturate the charge. This assumes the solutions at a specific gravity of 1.00, while in reality they have a specific gravity of about 1.25.

It requires about 40 per cent. of the weight of the charge in wash water for a reasonably good wash.

The acid consumption will not exceed 50 lb. H_2SO_4 per ton of charge and the salt lost in solution discard will not be more than 1 per cent. of the weight of calcine, probably much less. By figuring acid consumptions on each leach, and using acid content of each solution, before going on and after coming off the calcine, the acid consumption on the first 14 leaches averages about 25 lb. per ton. On the last six, 50 lb. of acid per ton was added. This may have given somewhat better results, but not very much so. It seems as though perhaps the extra acid of the 50-lb. consumption was used in taking up iron and alumina, and had very little effect on the copper remaining in the charge.

The silver has a tendency to precipitate on the lead linings to a small extent. This would not offer much difficulty, as the lead rapidly becomes coated and precipitation ceases. The solutions, on cooling and on the addition of water, drop some of the silver out as silver chloride. This forms in the bottom of the solution tank to more or less extent and has to be cleaned up periodically. All of the silver in solution precipitated in the scrap-iron launders with no trouble whatever.

Under conditions which would apply in a large plant, it is expected that an 85 per cent. extraction can be made on the copper, and very probably 86 or 87 per cent. A tailing carrying between 2 and 2¼ lb. of copper per ton should be made. In a plant as small as the 80-ton plant, and built for temporary use, a great many petty annoyances are encountered, as the running of the furnace, and therefore of the whole plant, depended on so many small pieces of machinery in the conveying and cooling equipment. Not 10 per cent. of the furnace shutdowns were caused by troubles with the furnace itself. Naturally, the furnace does much better roasting, and with less coal consumption, when it is running continuously or nearly so.

No salt is necessary in the roast for the better extraction of the copper. It would increase the silver extraction from 75 to 90 per cent, but this extra 15 per cent of the silver recovered would not pay for increased cost of salt, installation, and operation of an apparatus to catch the values in the gases. This recovery of fume values would probably not be much over 90 per cent. The chloridizing of the silver is done in the leaching tanks.

Precipitation of Copper from Solution at Anaconda

The paper on this subject by **Frederick Laist** and **F. F. Frick** points out that there are three general classes of precipitation methods: First, the use of iron, scrap

PHOTOGRAPH TAKEN AT THE UTAH MEETING OF THE AMERICAN INSTITUTE

or sponge; seconds, electrolytic deposition, and third, the use of some gas or reagent by which the copper is obtained, usually in the form of an intermediate precipitate which requires further treatment. For example, the precipitation of the copper as Cu_2Cl_2 from chloride solutions, with SO_2 gas.

The use of iron is adapted to almost any process. It has the great advantage of extreme simplicity, and the recovery of the copper and any values present in a highly concentrated, easily treatable form. The disadvantages are the cost in isolated places, the uncertainty of the scrap-iron market, and the fouling of the leaching solutions. The latter is a serious factor, when a reagent such as salt is used in them, which makes necessary their re-use.

Where applicable, electrolytic deposition is very attractive. The copper is obtained in a form directly marketable, there is a regeneration of acid and no fouling of solutions. Unfortunately, chloride solutions do not lend themselves to electrolysis. An entirely satisfactory anode material has not yet been discovered, although magnetic, apart from being rather brittle, seems to answer the requirements fairly well.

The use of a method of the third class is involved in many special leaching processes, and is highly attractive theoretically. Such methods usually involve regeneration of leaching solutions, no fouling of solutions, and the use of some cheap reagent, as lime, or a by-product of the process itself, or of some process such as smelting. Some method of this kind is undoubtedly that of the future where electrolytic deposition is not applicable.

The copper solution from the 80-ton leaching plant, in which the sand-treatment method now being installed on a large scale was developed, averaged Cu, 1.91; $Fe_2O_3+Al_2O_3$, 3.88; NaCl, 8.3 per cent.; Ag. 0.634 oz. The copper content of this solution cannot be increased much economically. The application of this solution to successive lots of roasted tailing, from which about 10 lb. of copper per ton can be recovered, would necessitate excessive washing of the tailing. The copper can be precipitated from this solution by means of scrap iron, the cement copper going directly to the blast furnaces or converters. The use of sponge iron is more attractive than the use of scrap iron, however. It can be made from calcines which contain about 50 per cent. iron. This makes the process independent of the scrap-iron market. But the use of iron necessitates the discard of about one-fourth of the solution each time to stop the accumulation of iron sulphate, and this leads to the loss of much valuable salt.

Owing to its high chlorine content the solution is not adapted to electrolysis. With a view to getting something better than scrap iron, precipitation experiments have been and are being conducted on precipitation by sulphuretted hydrogen made from matte (also from calcium sulphate), sponge iron from calcined concentrates, and sulphur dioxide from roasting-furnace gases.

The authors describe first their experiments with hydrogen sulphide as precipitant, then with sponge iron, and finally precipitation with sulphur dioxide.

To reduce the cuprous chloride, the authors have developed three different methods. First, precipitation with sponge iron ($Cu_2Cl_2 + Fe = 2Cu + FeCl_2$). Second, reductions with coke with limestone present to flux and hold the chlorine. Third, electrolytic reduction. The results obtained with these three methods are described in the paper.

The final conclusion of the authors is as follows:

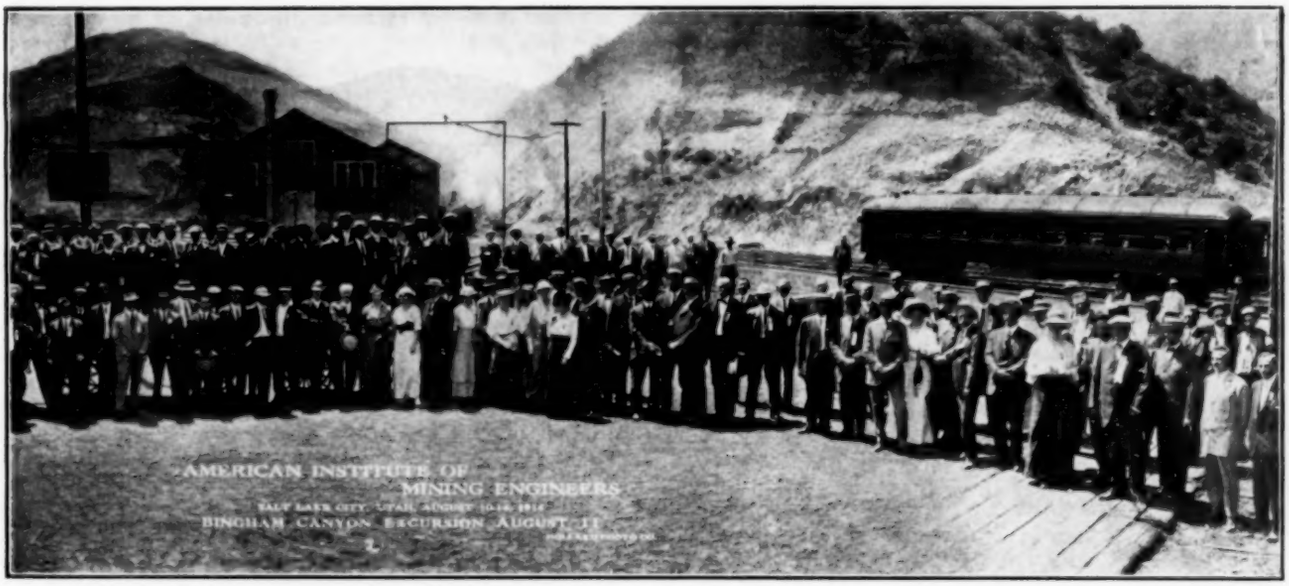
At present it seems advisable to precipitate the copper directly from the copper solutions of the 2000-ton sands-leaching plant with sponge iron. The precipitation of the copper from such solutions with sponge iron is being worked out and promises to be simple. Until the leaching process is established on a definite operating basis it does not seem advisable to introduce a complicated precipitation method.

The acid plant now building will have ample capacity for the first 2000-ton leaching unit. When the time comes to build further units, the installation of an SO_2 precipitation plant will depend on considerations of first cost of acid and precipitation plants, cost of operation and other factors which undoubtedly will develop.

Leaching Copper Products at the Steptoe Works

The paper by **W. L. Austin** describes a small copper-leaching annex to the Steptoe metallurgical plant, where ore of the Nevada Consolidated Copper Co. is beneficiated. This copper-leaching annex has been treating flue dust from roasting-furnace dust chambers, together with a siliceous oxidized ore. This leaching plant was designed to obviate smelting low-grade siliceous flue dust, which interfered with the operation of the reverberatories by forming a blanket on the charge.

The major portion of the copper content of the



OF MINING ENGINEERS WITH MINE OF UTAH COPPER COMPANY AS BACKGROUND

flue dust accumulating in the upper chambers of the roaster flue, and at the stack, is water soluble, and also contains much free sulphuric acid and soluble sulphates. It was found that sufficient acid could be obtained by mixing this material with water to provide a lixiviant for leaching the siliceous copper ore mentioned. This was the sole source of the lixiviant.

The flue dust analyzed copper 3 per cent, SiO_2 23, Fe 4., CaO + MgO 3., Al_2O_3 6., free H_2SO_4 20., SO_3 combined as sulphate 25., H_2O combined with the sulphates 11, O 2.5. Copper soluble in dilute H_2SO_4 2.56.

The oxidized ore, locally known as "carbonate," contains 3.5 per cent Cu, 71 SiO_2, 2 Fe, 9.5 Al_2O_3 — Copper soluble in dilute H_2SO 3.23. The copper in this ore is largely mineralized as silicate.

The method of operation pursued at the Steptoe plant consists in hydraulicking the piles of flue dust which have been withdrawn from the dust chambers, as an economical means of dissolving the soluble contents and of transportation to the tanks. The stream of water is conducted to vats, or impounded in dams, where the mud is allowed to settle. The clear solution resulting, which contains the soluble salts and is now the lixiviant, is drawn from these reservoirs to a wooden vat, fitted with a filter bottom. This is the ore-leaching vat proper. It is 40 ft. in diameter and 10 ft. deep. It is filled with crushed "carbonate" ore to a depth of 7 ft.; the ore column through which percolation of ¼-in. material is effected is therefore about 7 ft. high.

The excess space in this vat is used to store the lixiviant, for the hydraulicking operation is intermittent, while ore leaching is continuous. Enough lixiviant is accumulated above the charge in this vat to continue leaching during the night.

If the filtrate from the ore leaching vat (the lixivium) still contains considerable free acid, it is pumped back and passed through the ore bed a second time. Otherwise it is allowed to flow through a filter of "carbonate" ore, and thence over scrap iron placed in precipitating boxes.

About 85 per cent of the free acid carried by the lixiviant is utilized in the ore-leaching vat, the remaining 15 per cent. being left in the lixivium flowing over the scrap iron, to prevent formation of basic iron salts and insuring clean precipitate. About 2 lb. of scrap iron are consumed per pound of precipitate produced.

The cost of the copper recovered from the flue dust and siliceous "carbonate" ore capacity is approximately 8 cents per pound.

Leaching Experiments on the Ajo Ores

The paper by **Stuart Croasdale** gives a full account of the experiments carried out by him on the treatment of ores from the New Cornelia copper mine, Ajo mountains, Arizona, for the Calumet & Arizona Copper Company. Incidental with this problem was the utilization of a large amount of low-grade pyrite in the Bisbee mines of the company, provided this could be accomplished by any feasible method.

The ore deposit is unusual. It consists of an intrusive plug of monzonite or granite porphyry. Chalcopyrite, bornite, and magnetite are finely disseminated throughout the magma in sufficient quantities to make the greater part of the mass commercial ore to a certain depth.

The conditions of the problem demanded simplicity of process and large scale of operations. Two methods of *leaching* treatment were available, and both are entirely reliable and feasible under the conditions involved. One of these is the old Henderson process of roasting with salt, and the other is leaching the raw ore with sulphuric acid. Under the head of "chloridizing roast with salt," the author includes the so-called sulphatizing roast of Mr. Wedge, in which he finds the addition of a small percentage of salt very beneficial; and also the modification used by Mr. Laist at Anaconda, in which he reduces the consumption of salt, as well as the losses by volatilization, by giving the ore a preliminary roast before adding the salt.

A comparison of these two methods may be made briefly as follows:

By using the chloridizing roast, all ores on the property could be treated by the same process—oxidized, sulphide, and intermediate. This would mean the construction of only one plant. The average extraction of the copper would probably be higher than that obtained from acid leaching and the small amount of silver in the ore would be recovered to a large extent. By mixing the ores, little if any sulphur would have to be added as pyrite. The only chemicals required would be salt, to the extent of 5 to 10 per cent. of the ore treated, and possibly a small amount of pyrite ore. Both of these could be transported in ordinary freight cars. There

would be less corrosive solutions to handle. There would be a minimum amount of iron and alumina passing into solution. There would be no appreciable absorption of copper by slimes.

On the other hand, this method would require dry crushing of the ore to 20 or 40 mesh, which would be troublesome if not prohibitive on the oxidized ores on account of the difficulty in controlling the poisonous dust, in addition to the expense of grinding. It would involve a roasting cost. It would mean a more expensive plant, for the same capacity of operation, mainly on account of the slower percolation of the fine material, which would require a much larger vat area of less depth to hold the tonnage required. It would mean a supply of cheap salt. A chemical precipitant would probably have to be used to recover the copper.

By leaching with sulphuric acid, the oxidized ore can be treated raw and need not be crushed finer than ½ in. or 2-mesh size, or perhaps coarser, as the experiments of the author have shown. Owing to the high oxidation of the surface ores and apparently small zone of partly oxidized ores, a large tonnage can be expected to give a comparatively high extraction by this method. Sulphuric acid can be made as a by-product at the roasting plant of the Calumet & Arizona Company at Douglas, or if the calcines are converted into sponge iron and used as a precipitant for copper, the low-grade pyrite from Bisbee can be cheaply transported and acid made at the mine. If electrolytic precipitation can be used, a small percentage of the acid consumed can be regenerated. This method of extraction will permit of less expensive plant construction for the oxidized ores.

On the other hand, sulphuric acid alone will extract none of the copper existing as sulphide, only half of the copper existing as cuprite, and may be indifferent about the silicate of copper. It will extract none of the precious metals. Owing to the character of the oxidation of the ore, considerable iron and alumina pass into solution as readily as the copper, which will seriously interfere with any form of electrolytic precipitation and render the amount of acid regenerated a doubtful asset when compared with the amount consumed. As an offset to this objection, some of the iron is in a ferric condition, which assists materially in the solution of the minerals mentioned above.

If acid is made at Douglas, it will have to be transported several hundred miles in tank cars, which will have to be returned empty. If acid is made at the mine from low-grade pyrite, a gain will be made in transportation, but the cost of an acid plant will be added to the cost of the leaching plant and the calcines will have to be utilized. Almost an entirely new plant will have to be constructed for treatment of the intermediate and sulphide ores.

The problem is clearly one in arithmetic as well as metallurgy.

Laboratory experiments were made with both methods, experimental plant tests only with the acid leaching process. These tests are described in great detail in the paper.

The second part of the paper deals with *precipitation* of the copper from solution. The following precipitants are discussed: Natural sulphides of iron (unsuccessful, as far as the experiments went); artificial sulphides of iron (a failure); sponge iron (it seems feasible to metallize calcines for copper precipitation at a cost of not over $5 per ton of metallic iron); pig iron (the consumption of iron need not exceed 1 lb. for each pound of copper precipitated, provided the solutions are neutralized before precipitation) and finally electrolytic precipitation.

The vital factors governing electrolytic precipitation are cost of power, material for anodes, and interference of other metals.

The power required for deposition from clean copper sulphate solutions is about eight or ten times that required for refining purposes, or about 1 kw. per pound of copper deposited. The most economical current density is between 10 and 11 amperes per square foot and the voltage required is about 2 volts, although with magnetite anodes it is said a current density of 15 amperes can be used. With an average cost of electric power of not more than 1c. per kw. the power costs for this method of precipitation need not be prohibitive.

The anode material heretofore has been confined to lead or antimonial lead. Fused magnetite is now being tried and is said to be very satisfactory, although fragile and expensive. Its merits are yet to be demonstrated on a large scale. Lead anodes are gradually consumed, forming the peroxide of lead, which can be collected, reduced and used over again if necessary.

Interference of other metals has proved the chief stumbling block in most of the attempts to use the electrolytic method for the recovery of copper. Arsenic and antimony are troublesome, but are seldom found in appreciable quantities in leachable ores. Iron is the principal source of trouble and with it may be considered manganese if present, for its influence is substantially the same as iron. Iron, by its alternate oxidation and reduction, consumes electrical energy without the deposition of copper. It must, therefore, be rendered innocuous by one of the following methods: Removal by precipitation, the use of diaphragms, or the use of depolarizers.

The first two methods seem impractical, but the use of a depolarizer seems to offer a way out of this difficulty. The most feasible depolarizer and perhaps the only one sufficiently cheap for this purpose is sulphur dioxide. This has some advantages and some serious disadvantages. Theoretically, sulphur dioxide used in this manner will regenerate 3 lb. of acid for each pound of copper deposited. In experimental practice, 2 lb. has been the maximum obtained, owing to difficulties of manipulation. A certain amount of electromotive force is also generated in the direction of the current used, which reduces power consumption. These advantages, however, are more apparent than real.

If much iron and alumina pass into solution from the ore, the actual acid regenerated in the electrolytic cells is relatively too small to be of any importance. On these Ajo ores, granting the best possible regeneration of acid from electrolytic cells, the author estimated that 75 per cent. of the acid used will have to be made in an acid plant. In actual practice it would no doubt exceed this amount.

The mechanical difficulties in making the copper lixiviums absorb sufficient sulphur dioxide gas to produce the desired results have not been solved. Introduction of the gas into the electrolytic cells at the anode secures a very small absorption and renders the electrolytic plant uninhabitable for human beings. Acid makers of experience do not offer much hope of success for absorption of this gas by means of scrubbing towers.

Those who have tried to make sulphur dioxide act as a depolarizer on a commercial scale report these claims a fallacy.

Moreover, it has been found that when electrolytes containing sulphur dioxide are used the current density must be reduced to the neighborhood of 3 amperes per square foot in order to get a satisfactory deposition of the copper. This means an electrolytic plant installation three times the size ordinarily required.

It has been found impracticable to deposit copper from electrolytes containing less than 1 per cent. copper. The average lixivium including enough wash water and

acid to maintain a standard electrolyte will average between 1.5 and 2 per cent. copper. Assuming then, for the sake of argument, that 35 to 50 per cent. of the copper can be deposited in good form by electrolysis (35 per cent. is actually the case in the only plant in operation), if relatively large quantities of iron and alumina pass into solution at each cycle of the lixiviant it will be necessary to discard the entire lixiviant in a short time or a portion of it at each cycle, in which the copper will have to precipitated by a chemical reagent. This discarded lixivium will either be strongly acid, or, if neutralized by fresh ore, will carry its full quota of copper. In any leaching operation, there will be also a gradual accumulation of wash water or weak solutions, which will have to be treated with a chemical precipitant.

The conditions governing the successful deposition of copper from solution by electrolysis have been determined quite conclusively after long and careful experimentation by men skilled in the art.

With ores that will yield lixiviums free from interfering elements this method will no doubt prove a commercial success in spite of its expensive installation, but with ores like these where the iron passes into solution as readily as the copper, when the raw ore is leached with acid, it is almost a mathematical certainty that electrolytic precipitation cannot be made a commercial success and further experimentation along this line is useless.

A much more feasible method of overcoming this difficulty with iron would be to keep it from going into solution in the first place. This might be done by roasting the ore after crushing to the size required for leaching. The expense would be small. While there might be some danger of forming insoluble ferrites of copper, the iron and alumina would be rendered relatively insoluble in acid, the ore would be made more porous for leaching, there would be no argillaceous slimes to absorb valuable constituents, the copper sulphides and cuprite would be rendered soluble and the lixiviums might be clean enough for electrolysis.

The author's work was finished before this was tried.

Slime-Concentrating Plant at Anaconda

The paper by **Frederick Laist** and **Albert F. Wiggin** describes the new slime-concentrating plant at the Washoe Reduction Works, Anaconda, put into operation during March, 1914. This plant, which has a capacity of 26,000,000 gallons of slime pulp carrying 2,500 tons of solid matter per day, consists of Dorr thickeners and Anaconda multiple-deck slime concentrators. This plant is the culmination of a great deal of experimental work extending over a considerable period of time. This work is described in the paper.

The authors discuss the sources and amount of slime and its composition and then describe the experimental development work at Great Falls and Anaconda. These experiments related to slime thickening devices, slime-concentrators, dewatering of the slime-plant concentrate, the use of chemicals to accelerate the settlement of slime, and the effect of temperature upon the settlement of slime.

Finally a description of the Anaconda slime plant is given. The plant consists of three divisions, the slime-thickening division, the concentrating division, and the concentrate-dewatering division.

Chloridizing Leaching at Park City

The paper by **Theodore P. Holt** describes the plant of the Mines Operating Company at Park City, Utah, which was designed to treat the low-grade fillings in the old stopes of the Ontario mines. These fillings carry 6 to 14 oz. of silver, 1 to 2 lb. copper, 0.01 to 0.015 oz. of gold, and a small percentage of lead and zinc. The treatment consists in mixing the crushed ore with coal dust and salt and then roasting in a new type of furnace by combustion of the contained fuel. The roasted ore is leached with an acid salt solution to dissolve the silver, gold, copper, and lead. At present these metals are precipitated together on scrap iron and the product sold to a refinery.

The only new feature of importance in this scheme of treatment is the roasting process, which makes possible the chloridizing of ores without any loss of the valuable metals, and at a very low cost.

A paper by **James C. Ray** on microscopic study of Butte ores was finally presented and illustrated with stereopticon views.

Tuesday

On Tuesday the members were taken by a special train to the Bingham mines of the Utah Copper Company. The Bureau of Mines' rescue car was attached to the train for inspection. A rescue demonstration followed the visit to the Magna mill.

The Garfield smelter was next visited, where the reverberatory furnaces fired by oil and coal dust, and the nearly finished Cottrell electrostatic precipitation plant for converter fumes were of special interest.

In the evening session William Wraith presided, and the following papers were presented in the smelting symposium:

W. H. Howard, "Electric Fume Precipitation at Garfield."

L. D. Anderson, "Effects of the Bag House on the Metallurgy of Lead."

Lawrence Addicks, "Nodulizing Blast-Furnace Flue Dust."

E. L. Newhouse, "Lead Smelting at East Helena, Montana."

W. W. Norton, "A Comparison of the Huntington-Heberlein and Dwight-Lloyd Processes."

G. P. Hulst, "The International Lead Refining Plant."

On account of limitations of space, abstracts of these papers must be reserved for our next issue.

A complimentary smoker at the University Club followed the session.

Wednesday

On Wednesday the party was taken by a special train to the smelters at Murray, Midvale, and Tooele, Utah.

At the technical session in the evening C. W. Whitley presided. The subject was a symposium on zinc. The following papers were presented:

Dorsey A. Lyon and S. S. Arentz, "Losses of Zinc in Mining, Milling and Smelting."

R. D. Divine, "Separation of Lead, Zinc and Antimony Oxides.

S. E. Bretherton, "Treatment of Complex Ores."

H. A. Wentworth, "Electrostatic Separation at Midvale."

Earl T. Bardwell, "Effect of Annealing Upon Refined Copper."

C. D. Demond, "Economy and Efficiency in Reverberatory Smelting."

E. Horton Jones, "Unit Construction Costs for the New Arizona Copper Company Smelting Plant."

Dorsey A. Lyon and Robert M. Keeney, "Melting of Cathode Copper in the Electric Furnace."

C. R. Kuzell and I. H. Wigton, "Curves for the Sensible Heat Capacity of Furnace Gases."

L. O. Howard, "Basic Lines Converter Practice at the Old Dominion Plant."

On account of limitation of space abstracts of these papers must be reserved for later issues.

Thursday

At the Thursday morning session Sidney J. Jennings presided, and the following papers were presented:

John Van N. Dorr, "The Dorr Hydrometallurgical Apparatus."

G. H. Clevenger, "The Mill and Metallurgical Practice of the Nipissing Mining Company.

Robert H. Bedford and William Hague, "Tests of Rock Drills at North Star Mine, California."

E. D. Gardner, "Mining Claims Within the National Forest."

A large party made an excursion to Park City, where the Mines Operating Company's plant was visited, in which low silver ores are chloridized as described in the paper of T. P. Holt, noted above.

Banquet

On Friday night a banquet was held in the grill room, instead of the roof garden, of the Hotel Utah. It was a brilliant social event, graced by the presence of many ladies. Dancing followed.

The total attendance was about three hundred. W. L. Saunders acted as toastmaster, and speeches were made by President B. B. Thayer on "The American Institute of Mining Engineers," Bradley Stoughton on "Institute Ideals," Governor William Spry on "Utah," and E. M. Allison on "The General State of Affairs."

The whole meeting was most successful. Salt Lake City is wonderfully situated for such a convention on account of the great variety of mining and metallurgical operations, many of them being conducted on a tremendous scale. The hospitality of the Utah members was overwhelming.

Synopsis of Recent Chemical and Metallurgical Literature

Iron and Steel

Finishing Temperatures and Properties of Rails.—The main objects of an investigation recently completed by the Bureau of Standards, Department of Commerce, into the finishing temperatures and properties of rails were to determine, from measurements taken in representative rail mills, the present American practice regarding the temperatures at which rails are rolled; to demonstrate the ease and accuracy with which such temperatures may be measured; to find out what the "shrinkage clause" in rail specifications really means; and finally to determine for rail steels some of the physical properties, particularly those of interest in manufacture. Observations were taken with an optical pyrometer of ingot and finishing temperatures of rails in four representative mills. There is practical uniformity among the several mills for the rolling temperatures of ingots for steel rails, the range being from 1080° C. (1975° F.) to 1140° C. (2085° F.). There is no very considerable difference among the finishing temperatures of the rails as observed at the hot saws for the several mills, the range being about 880° C. (1615° F.) to 990° C. (1815° F.). Or, in other words, the four mills all finished their rails to within 50° C. of 935° C. (1715° F.) on the average. This temperature of 935° C. is 270° C. (520° F.) above the mean value, 665° C. (1230° F.) of the critical ranges of these rail steels. Concerning the distribution of temperatures within the head of a cooling rail, it is shown that the center of the head is some 50° C. (120° F.) to 60° C. hotter than the optical pyrometer reading at 935° C., therefore the center of the head is finished on the average at about 325° C. (615° F.) above the critical range for 100-lb. sections.

Chemical analyses and microphotographic examinations were also made and the mechanical properties determined for a number of samples of rail, the rolling of which had been observed. From a comparison of these few observations, there appears to be not a sufficient degree of correlation to warrant associating very specifically any of the characteristics defined by these three methods of examination, either with the temperatures of rolling here observed or with each other. The following thermal properties of these rail steels were determined in the laboratory:

The critical range on heating is located (maximum) to within 7° C. of 732° C. (1350° F.) for the 10 samples of open-hearth and Bessemer steels examined. On cooling the critical range lies between the limits 680° C. (1256° F.) and 650° (1202° F.).

The melting or freezing range for rail steel extends from about 1470° C. (2680° F.) to nearly the melting point of iron, located at 1530° C. (2786° F.).

The expansion for open-hearth and Bessemer steels is not the same. Above 800° C. (1470° F.) the expansion for both increases linearly with temperature and the linear coefficient per degree centigrade has the following mean values between 0° and 1000° C.

(1) For Bessemer steel (carbon .40 to .50%): alpha = 0.0000146.

(2) For open-hearth steel (carbon .65 to .70%): alpha = 0.0000156 to 0.0000161.

The average composition of the Bessemers was carbon = 0.40 to 0.50 and manganese = 0.76 to 0.93; of the open hearths, carbon = 0.66 to 0.70 and manganese = 0.66 to 0.72.

The American Society for Testing Materials in 1909 limited the shrinkage allowance on 100-pound sections to 6¾ inches in 33 feet, or to an equivalent of 1947° F. (1064° C.) for O. H. and 2055° F. (1134° C.) for Bessemer rails. This specification is still in force. Such a shrinkage clause therefore does not serve the avowed purpose of limiting the finishing temperatures to a value slightly above the critical range.

In conclusion, it should be emphasized that the various series of observations recorded in this investigation are of but a preliminary nature and do not pretend to solve the question of the relations between temperature of rolling and the properties of rails. It would seem desirable to make a much more complete and comprehensive study of the various matters mentioned and of related questions than has hitherto been attempted, and on a scale commensurate with the importance to the community of the problem of sound rails.

Alloys

Bronze.—In his recent paper before the (British) Institute of Metals, Mr. **John Dewrance** draws attention to the desirability of modifying the composition of bronze with the object of preserving its strength when used for high pressure and superheated steam. The paper gives the results of a large number of experiments which go to establish the fact that the addition of a half of one per cent of lead preserves the strength of the bronze up to 500 deg. and that without the lead bronze loses its strength at 350 deg. F. It is suggested that as lead has this effect it is probable that further investigation might prove that some other ingredient might preserve the strength of bronze at even a higher temperature. It is also shown that oxygen in bronze does not reduce the strength within practical limits.

Vanadium in Brass.—In a recent paper before the (British) Institute of Metals on the effect of vanadium on the constitution of brass containing 50 to 60 per cent copper, Messrs. **R. J. Dunn** and **O. F. Hudson**

describe experiments which were carried out with the object of ascertaining what, if any, was the effect of small quantities of vanadium on the constitution and structure of certain copper-zinc alloys, particularly with reference to the change which occurs at about 460 deg. C. in those brasses which contain the beta phase. A number of alloys containing small percentages of vanadium and inconsiderable quantities of impurities resulting from the reduction of pure vanadic acid by means of aluminium were tested thermally and microscopically. It was found that the critical point at 460 deg. C. was only slightly affected by vanadium, 1 per cent raising it not more than 10 deg. C. It was also found that the usual structure of brasses containing 50-60 per cent of copper is not greatly modified by the presence of small quantities of vanadium. Thus the observation of Carpenter that 1 per cent of vanadium causes the complete structural resolution of beta into alpha and gamma was not confirmed. Some of the alloys were subjected to prolonged annealing at temperatures just below 460 deg. C., and the conclusion arrived at was the vanadium to the extent of at least 1 per cent appears to have no influence on the structural stability of the beta constituent of the copper-zinc alloys. The authors also consider that if any structural resolution of beta into alpha and gamma follows the addition of cupro-vanadium to brass the result probably is due rather to the relatively large amounts of aluminium usually present in commercial samples than to the small percentage of vanadium remaining in the finished brass. In an appendix a brief description is given of the method of analysis adopted.

Corrosion of Brasses.—In a recent paper before the (British) Institute of Metals on the microchemistry of corrosion Mr. **Samuel Whyte** and Dr. **Cecil H. Desch** discuss the effect of electrolytic corrosion on the a-brasses of copper and zinc. The total corrosion is less than in the b-brasses, and there is less preferential removal of zinc. The alloy containing 1 per cent of tin is at first more corroded than a 70:30 brass, but as time goes on the corrosion is lessened, owing to the formation of a very tough layer of basic salts. The protective action of tin is attributed to this cause. One per cent of lead does not retard corrosion, as the residual coppery layer is very open in texture, but an alloy with 2 per cent of lead, (70:28:2) becomes covered with a very firmly adherent layer. This alloy was much less corroded than any of the others examined. Brass condenser tubes, corroded during service, have a structure which may be exactly reproduced by the application of an external electromotive force. This point is proved by photomicrographs. The apparent differences depend on the rate of corrosion and the supply of oxygen. When corrosion is slow and the oxygen supply abundant, the spongy layer of copper is converted into oxide as fast as it is formed, but otherwise a metallic dezincified layer remains.

Nickel in Copper-Aluminium Alloys.—In their recent paper before the (British) Institute of Metals Professor **A. A. Read** and Mr. **R. H. Greaves** discuss the influence of varying percentages of nickel on some mechanical and physical properties of the copper-aluminium alloys with 5 and 10 per cent of aluminium respectively. Hot rolling and forging tests showed that apart from increased hardness, and the necessity of a higher rolling temperature, the behavior on hot rolling of alloys with up to 7½ per cent of nicked was identical with that of the pure copper-aluminium alloys. Malleability and ductility are rapidly reduced by nickel in the 10 per cent aluminium series, but with 5 per cent of aluminium the presence of nickel increased the ductility as judged by the wire drawing tests. The main features of the tensile, hardness and alternating stress tests considered in conjunction with the microstructure may be stated briefly as follows:

(1) Alloys with 10 Per Cent of Aluminium.—Nickel up to 10 per cent in the chill castings gives increased maximum stress and yield point at the expense of elongation and reduction of area: 5 per cent of nickel gives maximum hardness; 5 per cent of nickel improves the annealed metal and diminishes the detrimental effect of annealing on the 10 per cent aluminium alloy. This composition corresponds to the limit of the alpha plus beta structure, increase of nickel above 5 per cent being accompanied by the separation of a blue constituent in place of beta. The effect of quenching on these alloys is similar to that on the 10 per cent aluminium bronze, but becomes less marked as the nickel increases.

(2) Alloys with 5 Per Cent of Aluminium.—Both in the chill castings and annealed rods, nickel has little effect on the hardness, maximum stress and yield point until 5 per cent is present. The ductility, however, is greatly increased by 1 per cent of nickel. With less than 5 per cent of nickel, the alloys consist of a homogeneous solid solution; with more than 5 per cent a second constituent separates on slow cooling, causing in the annealed rods a rapid increase in hardness, maximum stress and yield point with an accompanying diminution in elongation and reduction of area. The effect of quenching on the alloys with 5 per cent of nickel and over is to retain the second constituent in solid solution and thus to increase the ductility, while the hardness, maximum stress and yield point diminish. The rate of cooling need not be very great, for air-cooled rods gave results which approximate to those of the quenched.

The presence of nickel makes practically no difference to the specific gravity of these alloys: their melting points are raised, and conductivity for electricity greatly diminished. Corrosion by sea water is greatly reduced by the presence of nickel: there is no difference in behavior between the annealed and cold rolled metal. All the alloys with 5 and 10 per cent of aluminium and varying nickel behaved better both in fresh and sea water than either Muntz metal or naval brass.

Rapid Cooling of Binary Alloys.—Before the recent meeting of the (British) Institute of Metals Mr. **G. H. Gulliver** presented a paper which was a continuation of one read before the Institute last March. The methods then explained were now extended, so that the proportions of the constituents of a rapidly cooled binary alloy could be determined with a close degree of approximation whatever the curvature of liquidus and solidus. Results were given for the more important alloys of the copper-tin and the copper-zinc series, and for the copper-nickel series. A formula was devised for calculating the proportions of the constituents obtained with moderate rates of cooling when the liquidus and solidus are sensibly straight, and the results obtained from this for the lead-tin series were given.

Solidification of Metals from the Liquid State.—At the recent meeting of the (British) Institute of Metals Dr. **Cecil H. Desch** presented his first report on this subject to the Beilby Price Committee. The arrangement of crystal grains in a metal or alloy has usually been accounted for by growth of crystallites from independent centers. Against this, Quincke has proposed the hypothesis of foam-cells. On this view, the liquid separates immediately before crystallizing, into two liquids, which arrange themselves to form

a foam, and crystallization then takes place within the foam-cells. Quincke has applied the hypothesis to the explanation of many of the properties of metals. Several recent writers have also sought to connect the cellular structure with the prismatic partitioning of cooling liquids by convection currents. Whilst this arrangement may possibly be traced in some metals when cast in thin sheets, it cannot account for the structure of ingots or other large masses. The passage of metals in certain cases through an intermediate liquid-crystalline state has also been assumed, but not yet established. A review of the existing evidence suggests that several distinct cellular structures have often been confounded, and that a common origin has been assumed for structures which have a merely geometrical similarity.

The effect of undercooling, and the possibility of existence of two distinct classes of undercooled liquids is also discussed, as well as the changes of volume which occur during fusion and solidification. The determination of such changes is shown to be complicated by other factors, so that an increase in the external dimensions of a casting does not invariably represent an actual increase in the volume of metal. Lastly, the programme of experimental work now in progress, with the object of testing and comparing the hypotheses mentioned above, is briefly outlined.

Muntz Metal.—At the recent meeting of the (British) Institute of Metals Dr. **J. E. Stead** and Mr. **H. G. A. Stedman** presented a paper on the correlation of composition heat, heat treatment, structure and mechanical properties of Muntz metal. The authors having obtained a set of ½-in. bars of pure Muntz metal for the purpose of the research, heated them in duplicate in a tube furnace electrically heated for 48 hours to various temperatures ranging between about 500 deg. C. and 860 deg. C., after which treatment one of the heated bars, in each set, was quenched in cold water, the companion bar being allowed to cool in air. The cold bars were then examined microscopically and tested mechanically. Other bars were heated for three months at about 430 deg. C., and at 270 deg. C. for 984 hours and they were also tested and examined. The results appeared to dispose of the idea, held in some quarters, that Muntz metal could be burnt by high heating, and that quenching tended to soften brass, for while the annealed metal cooled in air had a tenacity of about 25 tons, the same material quenched from 812 deg. C. had a tenacity of 29½ tons—an increase of about 4½ tons.

The practical importance of the research is undoubted, as it shows:

First—That Muntz metal should not be annealed at temperatures between 750 deg. C. and 800 deg. C., as this is a range of danger, but it may be heated above 800 deg. C. without destroying its good quality.

Second—That it is made homogeneous and can be hardened to a considerable degree by heating to and quenching from above 800 deg. C.

Third—That the maximum degree of softness is obtained by long heating at the temperature of melting zinc—about 430 deg. C.

Fourth—That Muntz metal is very slightly oxidized by annealing even at 800 deg. C., and that the scale produced on the surface consists of zinc oxide free from copper.

The final part of the paper is devoted to the description of methods of tinting brasses so as to reveal their structure, and to the effect of hard drawing in leading to fractures in Muntz metal during service.

Report of Committee on Nomenclature of Alloys.—At the recent annual meeting of the (British) Institute of Metals in London the committee, consisting of representatives of the Institute of Metals, the Institution of Mechanical Engineers, the Institution of Electrical Engineers, the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, the North-East Coast Institution of Engineers and Shipbuilders and the Society of Chemical Industry, (chairman, Dr. W. Rosenhain, F.R.S.), present a unanimous report in which they recommend the adoption, first of a systematic nomenclature in which alloys are denoted by the names of their constituent metals in English, arranged in increasing order of percentage present in the alloys. This systematic nomenclature is intended chiefly for scientific and other purposes where its precise character more than outweighs its cumbrousness. The committee next recommends that a system of "practical" nomenclature should be set up consisting of "practical" names which are to serve as every-day abbreviations of the systematic or scientific names. The definition of current practical names on this basis has so far only been attempted in regard to the two important terms, "brass" and "bronze." The definition of "brass" adopted by the committee is that it is to be used as an abbreviation of the words "zinc-copper" as employed in the systematic nomenclature; when employed alone it indicates that the alloys are pure zinc-copper. Where the presence of other metals is to be indicated their names are to be prefixed to the term, forming such words as tin-brass, aluminium-brass, manganese-brass, etc. Similarly the term "bronze" is defined as an abbreviation for "tin-copper" as used in the systematic nomenclature, the definitions in other respects being identical as that for "brass." The committee is not yet prepared to recommend definitions of further practical terms, but the two terms defined represent the most widely used alloys, and their general adoption as thus defined would do much to remedy the state of confusion which exists at the present time. The committee, therefore, appeal to all those interested in the progress of the industries and sciences connected with metals to use their best endeavors to support and carry out the recommendations of the committee.

Oils

Iodine Number of Linseed and Petroleum Oils.—The determination of the iodine number of linseed and petroleum oils according to the Hanus method has just been completed by the Bureau of Standards of the Department of Commerce and the results published in Technologic Paper Number 37. Each of the three factors, weight of sample, time of absorption, and amount of Hanus solution was studied for a series of burnt linseed oils and petroleum oils. The results produced by variation of one of the factors, the others remaining constant, are reproduced graphically. Variations of weight of the raw linseed oil show that a constant volume is obtained for weights of the oil up to 0.25 gram. Beyond this value, the iodine number decreases with increasing weight. For burnt linseed oils, the range of weight over which the iodine value is constant, decreases with increased burning of the oil. Petroleum oils, on the contrary, approach a constant value when 0.6 gram or more of the sample is taken. Varying the time of absorption from five to sixty minutes shows that the reaction approaches a maximum in about ten minutes. Thereafter, absorption is slow, and a few minutes one way or another has little effect on the value obtained. When the amount of Hanus solution is varied from 20 to 75 cc. the results indicate that the oil with the

highest iodine number does not require the greatest excess of iodine to reach maximum absorption value. The effect of temperature on the value obtained is more marked for burnt linseed oils than for boiled or raw oils. The results as a whole indicate that concordance is obtained only when a prescribed procedure is followed with exactness. To obtain comparable results, a standard procedure should be followed in which the limits are strictly defined. This is particularly true of burnt linseed oils.

Notes on Chemistry and Metallurgy in Great Britain

(By our Special Correspondent)

Electric Mains Explosions

Last December the Board of Trade appointed a departmental committee to investigate the causes of explosions which were connected with cables laid in bitumen or sheathed with vulcanized bitumen at Hebburn, Nottingham and various other places. The report of this committee has recently been issued; and it appears that no serious cases of explosions have been disclosed nor was there any proof of instances where the supply was furnished by alternating current, by concentric mains, or by lead-covered paper-insulated cables, including three-core cables.

The faults occurred with single-core separate cables, sheathed with india rubber, or with vulcanized bitumen. And in all the cases of serious explosions which occurred in houses the cables were insulated with vulcanized bitumen; and such cables had either been drawn into bitumen casing or laid in bitumen on the solid system in troughs. Three causes of the deterioration of vulcanized bitumen are pointed out by the committee: (1) softening of the sheathing caused by coal gas; (2) corrosion of a conductor, consequent on a fault in a positive; and (3) faults to earth in a negative.

In the third class the conductor is not attached, but the insulating material is decomposed. Infiltration of moisture and osmosis render the bitumen pulpy and ultimately leakage occurs between positive and negative, or between middle and negative on the three-wire system, with the result that a short circuit is set up. When the resistance of the cable is sufficiently high the heat may only suffice to melt the adjacent bitumen which flows in, quenches the arc and seals the fault; but should the arc be persistent both the vulcanized bitumen sheathing and the trough bitumen would be melted and ultimately decomposed into gases which would form explosive mixtures with air.

However, the proportion of accidents which have occurred with vulcanized bitumen cables laid in solid bitumen has been so small in relation to the very large number of such cables in use that the committee is not prepared to recommend that approval of such system be discontinued. But the committee has arrived at the conclusion that the view that serious explosions are not likely to occur when pitch compound is used instead of bitumen for filling the troughs is justifiable. The committee is not able to recommend the exclusion of wood troughing in favor of iron or stoneware troughing, but does recommend the use of wooden troughing should be restricted to suitable soils.

In cases where separate mains are laid in troughing every cable should be laid in a separate trough; and there should be a space of not less than 2 in., tightly packed with earth or sand, between each trough. Separate mains for the supply of continuous current on the solid system should not be laid below pavement or close to the walls of houses; the bends at corners should be easy and the bitumen or pitch compound should be poured after the straight lengths have cooled.

With regard to the existing mains it is recommended that in all suspected cases of sharp corners the mains should be taken up and the corners eased, and that the service cables should be led into the houses in such a way as to preclude the possibility of the entrance of gas. Finally the committee recommend that the attention of engineers should be directed to the clauses of the Electric Lighting Act, 1899, and the Board of Trade regulations which enjoin notification of accidents by explosions or fire.

The Effect of Temperature on the Properties of Gun Metal

At the recent Conference of Shipbuilders and Engineers at Newcastle Prof. J. G. Longbottom and Prof. A. Campion contributed a paper on the influence of varying temperature on Admiralty gunmetal. The metal used for the whole of the experiments was composed of 87.96 per cent of copper, 9.77 per cent of tin, 1.94 per cent of zinc, 0.18 per cent of lead, and 0.13 per cent of iron.

Two sets of tests were made. In the first cast bars 15 in. long were cut into lengths of 7.5 in., screwed with ⅞ Whitworth thread on the ends and turned down in the middle for a length of 3.5 in. to a diameter of 0.564 in.; while for the second set cast bars about 10 in. long were screwed with 1⅛-in. thread for 2 in. at each end and turned down to a diameter of 0.798 in. for a length of about 5.5 in. in the middle.

During the tests the gunmetal bars with about 6 in. of each of the tension rods were placed in the center of an electric resistance furnace the temperature of which was taken with three platinum-iridium thermocouples. The results of the first series of tests showed very little change of strength from the initial temperature up to about 200 deg. C.; and, while the results from 200 deg. to 250 deg. were rather irregular, there was general indication of decrease of strength. As the temperature was further raised the strength continued to fall, until at 750 deg. there was practically none. At first there was an appearance of a slight increase of elongation with the increase of temperature, touching the maximum at 140 deg. C. As the temperature rose, however, it quickly fell, and at 350 deg. C. was less than 1.5 per cent. Thence up to 500 deg. there was but little alteration, with a slight tendency to an increase at about 400 deg. The modulus of elasticity was practically unaffected up to 200 deg., but diminished continuously with a further rise of temperature.

The second series of tests showed very little change in strength up to 200 deg., but above that point there was a steady continuous fall. Elongation and contraction of area both rose rapidly with the temperature, showing a maximum at 160 deg. for elongation, and at a slightly lower temperature for contraction. The ductility fell rapidly between 250 deg. and 350 deg. A sudden change in the direction of the curves occurred at about 350 deg. The modulus of elasticity showed similar variations to those in the first series.

The fact that the change in the direction of the curves uniformly occurred at the same temperatures appears to indicate that these temperatures are critical for the metal, and such change might therefore be attributed to changes in the phase relationship of the metal; but so far no critical points have been established in thermal curves of similar alloys at the point at which the sudden changes in mechanical properties occurred in these experiments.

The authors therefore infer that the changes in mechanical properties are not related to phase changes

in the alloy. They consider that their results are strong evidence of the existence of some kind of cement between the crystalline particles of the metal. At certain temperatures marked slips occur after the yield point is passed, not only with nonferrous metals but also with steel; and sometimes these slips are of such extent that the steelyard falls on the bottom stop as if fracture of the specimen had occurred. But after a short interval the metal recovers and bears a further load.

The authors are of opinion that this phenomenon may be explained by the amorphous cement recrystallizing and causing a reduction of adhesion between the crystals of the metal sufficient to permit some of those crystals to separate from their neighbors under the stress, while actual rupture is prevented by the friction of the crystal faces against each other under sufficient pressure to re-form a quantity of the cement into an amorphous condition, thus partly restoring adhesion.

The reconstituted amorphous material becomes again crystalline by the influence of heat and another slip occurs; so that there are alternate transformations into crystalline and amorphous material, with corresponding decreases and increases of strength. Moreover, during the latter series of tests an appreciable increase in temperature of the gunmetal was observed immediately after each slip; and this is just what might be expected as the result of the recrystallization of the amorphous cement.

The Strength of Oxy-Acetylene Welds

The same Conference of Shipbuilders and Engineers also brought forth a paper by Prof. A. Campion and Mr. Wm. C. Grey which gave the results of tensile and impact tests of oxy-acetylene welds. The authors remarked that under working conditions the material was usually subjected to repeated shocks; and they had, in addition to static tests, compared the effects of repeated impact on welded and unwelded metal. The material used was mild steel containing about 0.25 per cent of carbon. For the first series bars $\frac{5}{8}$ in. in diameter were turned down for a length of $1\frac{1}{2}$ in. at the weld to $\frac{3}{8}$ in. in diameter, the elongation being taken on a 1-in. length. Contraction of area was not recorded because most of the fractures were too ragged to allow of measurement. The results indicated that an average weld would have about four-fifths of the strength of unwelded steel, while the ductility would be only about one-fifth. There was no great variation in maximum tensile strength, but ductility varied widely from the average; for, the lowest strength of welded metal was about 80 per cent of that of the original steel, and the lowest elongation was only 9 per cent.

Ductility was increased by hammering; but the strength was lowered. Reheating after hammering improved both the ductility and the maximum stress. Reheating at the same temperature without hammering caused a comparatively large rise in ductility and a small rise in the strength. Quenching in water and reheating brought the strength up almost to that of the unwelded steel but diminished the elongation.

For the impact tests bars $6\frac{1}{4}$ in. long and $\frac{1}{2}$ in. in diameter were notched in the center of the welded part to a diameter of 0.4 in. The results again showed great variation, and suggested that an average weld would resist only half as much fatigue as unwelded metal. Hammering improves the weld in this respect, but the metal should be reheated at a full red heat—800 deg. C.—to avoid production of strains or brittleness. Reheating or annealing without hammering has but little effect. The treatment which produced the best results in the tensile tests gave the worst in the impact tests.

Further experiments with the bars notched at the edge of the weld instead of at the center were made to ascertain the influence on the whole weld of the overheated zone produced during welding, and the results varied still more than those given by centrally notched bars; but while the hammered specimens of the latter gave 84.4 per cent of the original strength the hammered side-notched bars gave only 57.7 per cent. Impact tests on plates of different thicknesses showed conclusively that the reliability of the weld and the strength decreased as the thickness increased.

The authors conclude that very serious responsibility is incurred by using autogenous welding in parts which may be subjected to any considerable strain.

Iron and Steel Alloys

Sir Robert Hadfield, in his presidential address to the Faraday Society, remarked that Faraday did a great deal of pioneer work in researches connected with the alloys of steel. He was of opinion, however, that research work on the compounds of iron and carbon had not been sufficiently followed up; and to emphasize the importance with which he regarded such work he offered two prizes of £200 each to the Iron and Steel Institute and to the American Institute of Mining Engineers for the best paper or research on the subject.

Metallurgists were now speaking of carbides, subcarbides, double-carbides and other compounds, but it was most desirable that those substances should be thoroughly investigated and defined. Moreover it was desirable to ascertain the state in which the carbon existed. A certain form of carbon in iron and steel was referred to as a "missing" form, and but little is understood about it; and more information about this form of carbon is required because it was desirable to know whether the carbon not determined as a carbide is "missed" because of its existing in an extremely fine state of division or whether it is in some special form of combination.

With regard to the alloys of iron with elements other than carbon, the fact that in such steel carbon holds a position of supreme importance should not be lost sight of; for with few exceptions its presence in these special alloys was indispensable. For example, in high-speed tool steel, although the carbon content need not be relatively high, yet it must be great enough to ensure the cutting properties of the steel being attained.

As a probable explanation he mentioned that in modern high-speed tool steel there is generally 16 to 20 per cent of tungsten and 2 to 4 per cent of chromium and about 0.74 per cent carbon. Previous to heat treatment the carbon exists in the steel both as carbide and as hardening carbon as defined by Ledebur—0.56 per cent of the former and 0.18 per cent of the latter; but after heat treatment and when the cutting edge of the tool had been brought to the requisite condition, the hardening carbon amounted to 0.6 per cent and the carbide carbon to 0.14 per cent. Consequently the effect of the addition of elements other than carbon must be regarded as entirely due to the change brought about by heat treatment in the form in which the carbon exists by converting it from carbide carbon into what is termed hardenite; and the elements employed as alloys enabled the hardening carbon to retain its properties in a cutting steel. Heat treatment produced a similar change in any low-carbon steel which did not contain other elements except, perhaps, in very small quantities; but the tungsten and chromium in high-speed steel appear to help to maintain the hardenite as hardenite, and consequently the cutting edge did not lose its hardness, even when the friction caused very considerable rise of temperature, such as would soften ordinary steel.

In 1903 he carried out experiments with two kinds

of steel. both of which contained similar quantities of chromium and tungsten, but one had a carbon content of 0.35 per cent and the other a carbon content of 0.74 per cent. They were both subjected to heat treatment at 1100 deg. C. and cooled in air, when the steel with the higher carbon content contained 6.6 per cent of hardenite and was an excellent tool steel. The other sample contained practically no hardenite; almost all the carbon existed as carbide; the metal was soft, would not carry a cutting edge and was useless as tool steel.

The importance of investigating the alloys of iron was not to be measured merely from the point of view of getting the exact combination required for any purpose, but also by obtaining the maximum degree of utility from a given quantity of metal. A pound of alloy tool steel would go as far as many pounds of ordinary metal, and although the former was more expensive it was really a saving.

In the United States some 33,000,000 tons of pig iron were now being produced per annum; Germany turned out about 20,000,000 tons, whilst the total output of Britain, France and Belgium amounted to nearly as much more. This enormous consumption of iron ore could not be maintained indefinitely, and we might probably before long find it desirable to husband our resources of iron ore more carefully than we did at present.

Great Britain had now gone down to the third place among the nations in the production of pig iron, but we were more prosperous than ever, and the tonnage production was, therefore, not a decisive index so long as we could maintain a cheap supply of ore, pig or bar iron. But of course the most important point was the provision of the requisite supply of ore. Henri Gaston pointed out in his "Ou va l'Allemagne?" that Germany will shortly exhaust her own supplies of ore and does not control any outside sources of notable value. M. Gaston claims that the metallurgical future of France will be much greater, and he says "We are destined, if nothing happens to counteract our designs, to become the most powerful metallurgical nation in the world."

The National Physical Laboratory

The annual meeting of the general board was held on Friday, June 19, under the presidency of Sir William Crookes. The work and equipment of the laboratory have made great progress during the past year, and the total value of the goods represented by the materials tested was approximately £300,000. The research carried out by Mr. F. E. Smith on the absolute measurement of the standard of electrical resistance resulted in his finding that the international ohm is equivalent to 1.00052 x 109 C. G. S. units of resistance, or, in other words, the length of the mercury column representing the true ohm should be 106.245 cm., instead of 106.3 cm.

The total income of the laboratory for the year 1913-14 was £43,713 as against £32,058 in the preceding year, and the respective expenditures were £40,968 and £32,479. Consequently the year under review showd a credit balance of £2,745, whilst in 1912 there was a deficit of £420. The experimental tank building fund was deficient to the extent of £2,661, and part of the general balance would be applied to the reduction of this debt.

No doubt from the point of view of the directors of the National Physical Laboratory the increase in their income is very satisfactory; but, having regard to the fact that that increase of income is largely derived from a further diversion of work from professional men in private practice, it is doubtful whether the leading scientific and technical societies will look on the matter with the same degree of satisfaction. The national purse will provide the N. P. L. with all the funds requisite for the carrying out of its legitimate work; and there is no necessity for its entering into competition with the chemist, the metallurgist, the engneer and the electrician.

Humphrey Pumps for the Egyptian Irrigation Department

The level of Lake Mariut, into which the drainage of the Behira district should flow, has become so much raised that it is no longer possible for the water to adequately make its way into the lake, which has a depth of only about 3 ft. with an area of some 50,000 acres, and which is divided from the Mediterranean Sea by a narrow strip of land having an elevation of 20 ft. or less above the surface of the lake. It has been decided to erect a pumping station at Mex, near Alexandria, for the purpose of discharging into the sea the water from a large canal which is now being cut through the dake. The first installment of the plant will consist of ten Humphrey pumps capable collectively of delivering 980,000,000 of gallons of water in 24 hours, with a lift of about 20 ft.; but two pumps will be kept in reserve. It is proposed to add another set of ten similar pumps afterward. The combustion chambers of these pumps will have a maximum diameter of 8 ft. 8 in. and a height of nearly 14 ft., while the water valve boxes will have only half that height with the same diameter, and will each be furnished with 100 hinged valves of new design. Each of these pumps will have about two and a half times the capacity of the large Humphrey pumps at the Chingford station of the Metropolitan Water Board. They are being constructed by two British firms.

Power will be supplied from an anthracite Mond gas plant gassifying 44 tons per day with a guaranteed consumption of 1.15 lb. of coal per water horse-power.

An electric power and lighting plant will also be put down consisting of two 180-b.h.p. gas engines coupled directly to 120-kw generators supplying current at 220 volts.

The Institute of Metals

The Employment of Non-Ferrous Metals in the Navy

Sir **Henry J. Oram**, engineer-in-chief of the fleet, in the course of his presidential address to the institute, gave some very interesting figures relating to the amount of non-ferrous metals used in the construction of our battleships and cruisers at the present day as compared with 20 or 25 years ago.

At the present time for every hundred tons of iron and steel used in the construction of a battleship there were about six tons of copper or copper alloys, whilst in a cruiser the proportion of copper and its alloys amounted to eight tons. The higher proportion of non-ferrous metals used in the construction of a cruiser was owing to the smaller weight of armour carried and the increased power of the machinery which, of course, necessitated the employment of a proportionately greater amount of non-ferrous metals than did the hull and other structures.

With regard to the propelling machinery, the proportion of non-ferrous metals in a modern battleship was some 17 per cent of the steel and iron. Twenty years ago the corresponding proportion of non-ferrous metals was some 34 per cent.

The proportionate amount of non-ferous metals, however, had not been similarly reduced in the structure of the hull, and the greater increase in the employment of steel had been counterbalanced by the large increase of non-ferrous metals employed in gun turrets, controlling apparatus, electric lighting and so on, so that excluding the propelling machinery the

whole structure of a battleship now contained about 4.4 per cent of non-ferrous metals in relation to the amount of iron and steel, as against 4.2 per cent 20 years ago.

A great deal of careful attention had been given to condenser tubes, which simple articles had an important effect on the reliability of the ship's machinery. Corrosion of condenser tubes constituted a very important defect but some of the worst troubles experienced in the navy have arisen not so much from corrosion or perforation as from splitting of the tubes whilst at work and although the total failures due to corrosion and perforation largely exceeded the number due to splitting, the consequences of the latter mishap were very much more serious. In the year 1908 there were approximately 2,500,000 condenser tubes in use at sea in the fleet, and the number of failures reported as having occurred on service were: splitting 21; corrosion and perforation 69; giving a total of 90, which was equal to one tube failing in 28,000 for the year.

The 1913 returns showed approximately 3,800,000 tubes in use, and the total number of failures reported as having occurred during the years 1912 and 1913 were: splitting 16; corrosion and perforation 115; giving a total of 131, which was equal to one in 60,000 per year, which figures showed a very satisfactory reduction.

Company Meetings and Results

John Brown & Co. Ltd.—Lord Aberconway presided at the annual meeting on June 30, and remarked that he considered the balance sheet to be the best and strongest ever presented by the company. The balance amounted to £467,000; out of which, after paying the usual preference dividend and 10 per cent on the ordinary shares, £100,000 would be appropriated to extensions and £96,000 carried forward to next year's account.

General Electric Co., Ltd.—The ordinary general meeting was held on July 2, when Mr. Hugo Hirst presided. The net trading profit for the year was £157,893, and the total balance was £190,224. After due provision for depreciation, placing £30,000 to reserve account, and putting £14,000 toward the expenses of the recent increase of capital, this sufficed for a dividend of 10 per cent on the ordinary shares and to carry forward £36,739.

Victoria Falls and Transvaal Power Co., Ltd.—The annual general meeting took place on July 8 under the presidency of the Marquess of Winchester. For the year 1913 £467,823 were carried to appropriation account, £21,443 more than in the previous year. Interest on debentures absorbed £203,920; £135,491 were applied to depreciation, and £128,411 carried to credit of profit and loss account which showed a balance of £225,198, out of which dividends at the rate of 6 per cent per annum had been paid on the preference shares for the year 1912. The dividends amounted to £120,000, leaving £105,198 to the credit of profit and loss account as a reserve at the beginning of the year. It will be seen that the preference dividend is twelve months in arrear.

Mond Nickel Co., Ltd.—Sir Alfred Mond presided at the annual general meeting on July 6. A number of new properties had been acquired and developed during the year. The profit and loss account showed a balance of £297,000 against £232,000 for the previous year. After deducting the amount of the interim dividend on the preference shares the available balance was £284,000.

The directors proposed to pay the usual dividend on the preference shares, 35 per cent on the ordinary shares, a dividend of £79,000 on the deferred shares, and to carry forward £91,000.

Brunner, Mond & Co., Ltd.:

The report for the year ended March 31st shows a profit of £769,344. O. O. It is proposed to pay a dividend on the ordinary capital amounting, with the sum paid on December 12th, to 27½ per cent for the year, less income tax. £2,500 O. O. is written off patents account and £110,921 O. O. is carried forward.

The Bleachers' Association:

The account for the year ending March 31st shows a net profit of £666,045 O. O., after placing £210,865 O. O. to repairs and maintenance account, £15,000 to leasehold and sundry property account and £60,000 to depreciation. £50,000 will be transferred to general reserve, £60,000 to reserve for equalization of dividends and £15,000 to fire insurance.

A dividend for the six months ended March 31st of 7 per cent on the ordinary shares is recommended, making 6 per cent for the year. £173,957 is carried forward.

Market Prices

July, 1914

	£ s d
Aluminum, ingots, ton lots	86. 0. 0
Alum lump, loose, per ton	5.10. 0
Antimony, Star Regulus, ton	26.10. 0
Borax, British refined crystal, cwt	17. 6
Copper sulphate, ton	20.10. 0
Caustic soda, 70%, ton	10. 0. 0
Copper ore, 10% to 25%, unit	10/4½ to 10.10½
Ebonite rod, lb	4. 6
Hydrochloric acid, cwt	5. 0
India-rubber, Para, fine, lb	2.10¼
Mica, in original cases, medium	3/— to 5. 0
Petroleum, Russian spot, gal	9¼
Quicksilver (Spanish) bottle	6.15. 0
Sal-Ammoniac, cwt	2. 2. 0
Sulphate of ammonia, ton	11. 8. 0
Sulphur, recovered, ton	5.10. 0
Shellac, cwt	3. 5. 0
Platinum, Oz., nominal	9. 5. 0
Tin ore, 70%, ton	92. 0. 0
Zinc, Vielle Montagne	25. 2. 6

Copper opened at £61 and rose till the 6th when it was £62 10s., then declined till the 10th to £61 7s. 6d., and recovered till the 17th £61 6s. 3d., but had again reached £61 by the 20th and £60 10s. by the 23d. It fell on the war news to £58 on the 28th and £57 on the 29th.

Tin opened £140 15s. and after a slight decline rose rapidly to £145 15s. on the 6th; after another slight decline it reached £147 5s. on the 9th. It then fell away to £142 17s. 6d. on the 15th, but had recovered to £145 17s. 6d. on the 20th.

On the 28th it was £135 10s. and on the 29th the same price.

Haematite opened at 61s. and remained steady at this price throughout the month.

Scotch Pig opened at 57s. and appreciated fairly steadily to 57s. 7½d. on the 8th and then dropped slightly, recovering to 57s. 6d. on the 14th and closes 57s. 3d.

Cleveland opened at 51s. and improved till the 8th when it was 57s. 7½d. It then declined a little, but recovered to 51s. 6d. on the 14th, afterward dropped to 51s. 4½d., remaining at this price till the 20th and closing lower, 51s. 1½d.

Lead opened £19 10s. and had risen to £19 15s. by the 6th and £20 by the 9th, but was weaker on the 13th, and had again fallen to £19 10s. by the 16th, keeping at this price till the 20th but afterward declining and reaching £19 5s. by the 28th.

Differences in the Month

Higher	£. s. d	*Lower*	£. s. d
Aluminium, ton	1. 0. 0	Antimony, ton	0.10. 0
Sulphate of ammonia	10. 0	Copper sulphate, ton	10. 0
		Mica	0. 6
		Quicksilver	5. 0
		Tin, ton	5. 5. 0
		Copper, ton	4. 0. 0

Concentrating Unsized or Unclassified Ore-Pulp

A new ore-concentrating machine having the general appearance and mode of operation of a concentrating table, but acting more on the principle of a jig, is the Isbell concentrator, manufactured by the Denver Engineering Works Co., Denver, Colo. The device is a radical departure in concentrator construction, and embodies some novel features in its operation. Preliminary classification or sizing is dispensed with; there is no transverse current of wash water; concentrate pockets deliver the concentrate through the deck of the table, while tailing and middling pass over the end; the general movement of ore-pulp is coincident with the progressive motion of the table.

A view of the concentrator from the tail end is shown in Fig. 1. It consists of a riffled deck divided into two similar sections by a longitudinal partition, each section having a feed-box, riffles and six concentrate pockets which are supplied with hydraulic water from above. The deck is mounted on steel base-frame and steel spring supports, and carries the concentrate launders underneath. The drive imparts a differential reciprocating motion to the deck. The riffles converge from the edges of each section to the central line of concentrate pockets, and their use is mainly to direct the stratified concentrate to the pockets. A section through one of these pockets is shown in Fig. 2. In a measure it constitutes a classifier, inasmuch as the hydraulic water flowing against the entering stratum of concentrate effectually sorts and washes back any gangue particles that may be included.

The operation of the concentrator is unusually simple. Ore is ground to, say, 6-mesh, and without classification or sizing or removal of slime, is fed onto the reciprocating deck of the table with enough water to make the pulp flow readily. The motion of the deck

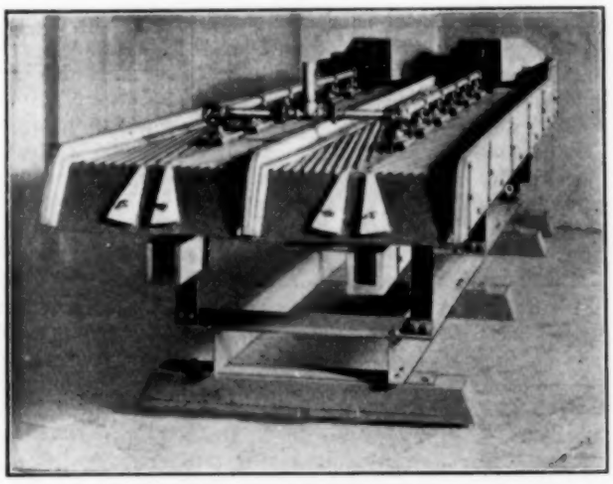


FIG. 1—ISBELL CONCENTRATOR

causes the particles of pulp to stratify according to their relative specific gravities, and the heaviest mineral particles settle into the riffles, with the gangue lying above. As the pulp progresses along the deck the settled concentrate is directed by the riffles into one of the concentrate pockets where it encounters a light stream of water under pressure sufficient to wash back any gangue, while allowing the concentrate to enter and pass out through the discharge tube. Any valuable mineral that does not settle and pass into the first pocket is caught in one of those farther down the table. The gangue flows over the pockets. Finally, anything passing the last pocket is presumably either middling or tailing, and these are separated by the last set of riffles and divided on the tail board by means of adjustable partitions.

On a machine of this type the practice of treating an unsized or unclassified feed is not as unorthodox as it sounds. It is well known, for instance, that the motion usually appllied to a gold-pan filled with coarse and fine ore and water results in gathering all heavy mineral or metal in a bottom layer, irrespective of the size of those particles. Similarly, the Joplin jig treats an unsized product, with the result that practically all the free mineral settles through the pulp, the coarser particles being retained on the bed, while the fine pass through it into the hutch. In the same way the unsized

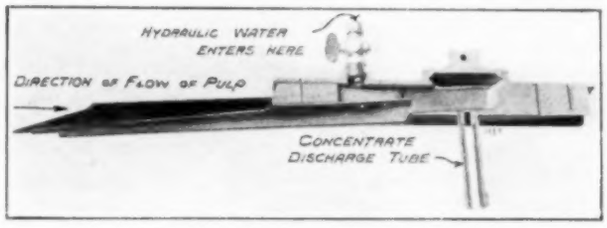


FIG. 2—CONCENTRATE POCKET ISBELL CONCENTRATOR

pulp fed onto an Isbell concentrator becomes stratified, and all heavy particles, irrespective of size, accumulate in a bottom layer that is subsequently guided by the riffles into the pockets and discharged. By regulating the stream of hydraulic water entering the pockets, the concentrate may be discharged with a varying quantity of gangue.

A number of advantages are claimed for this new concentrator. It has a large capacity, ranging from 50 to 100 tons per 24 hours, due to the method of handling the ore in a deep bed, and the separation of mineral from gangue by jigging action without the use of a transverse current of wash water. Preliminary sizing is unnecessary, and the usual devices for this work can be omitted from the mill system. Fine or slime mineral is readily recovered as long as it is treated with the coarse. The machine requires about the same power as do ordinary concentrating tables. The quantity of water required for regulating the action of the concentrate pockets varies from 7 to 15 gal. per min., under a head of about 15 ft.

The Application of Cold, Cleaned Producer Gas to High-Temperature Regenerative Furnaces

Under this title Mr. H. F. Smith, general manager of the Smith Gas Power Company of Lexington, Ohio, has published an interesting bulletin on this company's system of generating and distributing producer gas.

In order to characterize first some general features of this system, it may be said that the Smith producer is a mechanically operated suction producer. The shell, lining, and other heavy parts are stationary, and the agitation of the fuel bed is attained by the movement of the grate bars. A centrally located gas outlet is provided which prevents channeling along the producer lining. In conjunction with this is a magazine feed. The grate area is ample so that the rate of gasification is moderate and the production of high temperatures is avoided. The grate surface is large and concentration of the blast at this point is avoided. The ash-pit space beneath the grate is segregated, permitting the distribution of the blast to various parts of the fuel bed to be accurately controlled. The stoking mechanism is also segregated so that the stoking action

can be accelerated over any portion of the fuel bed.

Smith producers are provided with the saturator system of vapor control about which more will be said below. The gas output is automatically controlled as to volume and quality and the manipulation of the producer is entirely independent of any conditions that may be imposed at the furnace by the furnace man.

Smith gas is cleaned and cooled before being delivered to the gas mains. The volume of gas to be handled is only about one-fourth that issuing from hot gas producers from the same volume of fuel. The gas may, therefore, be distributed through small unprotected steel pipes. There are no deposits in the mains. While the gas is cooled and cleaned, this is claimed not to involve any loss in thermal efficiency from the precipitation and removal of tar, since provision is made whereby the waste heat contained in the discharge gases from the producer is utilized in converting the tar into fixed gas. With the Smith system both ammonium sulphate and tar can be recovered in marketable form if desired.

Finally a high efficiency is claimed for the Smith producer. "While there is apparently a loss of heat units resulting from the cooling of the gas, this loss is for practical purposes more apparent than real and in regenerative furnaces Smith gas will produce a greater heating effect per pound of coal than can be produced from the same quantity of fuel when gasified in the so-called hot gas producer." This statement will probably meet with opposition, and it will, therefore, be interesting to analyze later Mr. Smith's argument in favor of this claim. But we may first discuss the technical principles by which uniformity of gas quality is obtained in the Smith gas producer. It is based on three principles, (*a*), (*b*) and (*c*).

(*a*) Maintenance of uniform ratios between air and water vapor in the blast to the producer. This is obtained by the use of the "saturation system" in which the air supply to the ash-pit is preheated and saturated with water vapor by being brought into contact with large surfaces of hot water. "With the Smith saturation system not only can the presence of an excess of vapor in the blast be entirely prevented, but any excessive amount of moisture in the gas, from any cause whatever, either through firing of wet fuel, through the liberation of contained moisture from the coal, or from the passage of undecomposed steam through the fuel bed, will be removed by the subsequent cooling of the gas which causes a condensation of any excess of water vapor from whatever source. Accordingly, with the Smith system, the delivery of excessive amounts of vapor to the furnace with the gas is absolutely prevented."

(*b*) Maintenance of uniform rates of distillation of hydrocarbons from the coal. To obtain this in the Smith producer, the fuel supply is uniform from large fuel magazines above the active fire zone into which coal can be discharged as required without producing any disturbance of the gas-making conditions whatever. The fuel descends into the gas-making zone only so fast as the coal below is consumed and in this way sudden fluctuations in the hydrocarbon content of the gas is avoided.

(*c*) Maintenance of uniform temperatures and ample time of contact between the fixed carbon and the blast in the body of the producer. This is obtained by the large grate surface provided and a moderate rate of driving the producer.

The chief novelty of the whole system is to be found, however, in the use of a cold, cleaned gas in the Smith system as against the usual hot producer practice. Naturally Mr. Smith pays considerable attention to this point in his pamphlet. For the purposes of this review it may be considered from three different viewpoints: efficiency of generation of the gas, of its distribution, and of its utilization at high-temperature regenerative furnaces.

EFFICIENCY OF GAS PRODUCTION

With respect to the *generation of the gas* in the Smith producer the energy balance sheet would show (1) a useful consumption of energy. "The efficient production of gas by the producer process is dependent upon the carrying out of a number of *heat-absorbing* reactions within the fuel bed." The gas in leaving the producer carries with it chemical energy which becomes available in form of heat when the gas is burned with air. (2) Losses in form of unburned carbon in the ash, in form of heat loss by radiation from the producer walls, and in form of sensible heat carried out of the producer by the gas.

Losses in unburned carbon are reduced to a minimum by providing a large grate surface and by a slow rate of driving the producer.

This slow rate of driving also makes it possible "to carry out completely the chemical reactions involved in gas making without carrying the temperature of the fuel bed above very moderate figures." Further the central gas outlet tends to divert the blast from the producer lining so that excessively high temperatures in the latter are avoided and the radiation loss from the producer walls is reduced.

"The most important source of heat loss from the producer is the heat carried over by the discharge of the gases at high temperatures. At this point is wasted not only that unavoidable portion of heat which represents the temperature at which the fuel bed must be maintained for proper working, but also the additional heat losses which results from imperfect and incomplete chemical actions of all sorts within the producer itself. . . . The most direct index, therefore, of the efficiency with which the various chemical reactions in the producer are carried out is the temperature of the gas discharged from the machine. If these reactions are complete a maximum amount of heat will have been absorbed and its energy converted into latent chemical energy in the gas. On the other hand, if the reactions are incomplete, this fact will be indicated invariably by waste of heat which results in higher gas temperature."

At the Alton plant using a Smith producer the average temperature of the discharged gases is between 750 and 800 deg. F. At the Smith Gas Power Company's factory the average temperature of the discharge gases at the point of leaving the producer shell is from 350 to 555 deg. F. Both temperatures are much lower than in usual hot gas producer practice. If an average value for the latter is taken as 1600 deg. F. and the temperature of the exit gases in the Smith producer as 700 deg. F., Mr. Smith figures that this temperature difference of 900 degrees represents a loss of 1620 B.t.u. per pound of coal—quite an appreciable loss.

The whole argument of Mr. Smith is decidedly interesting. It would be very illuminating to get for comparison an exact numerical energy balance sheet for the Smith producer and for a hot gas producer, with detailed analyses, temperature records, etc. There is surely no flaw in the argument that *if everything else is the same*, except the temperature of the gases leaving the producer, the producer with the lower gas temperature is the more efficient one.

But a few questions would seem to suggest further investigation. If we keep the temperature in the producer purposely down, how do we change thereby in detail the chemical reactions? The final net result seems very satisfactory, as indicated by the composi-

tion of Smith producer gas, given as the average of five analyses made at different times at different plants, using different grades of bituminous coal: 5.2 per cent CO_2, 0.9 O_2, 25.0 CO, 4.3 CH_4, 14.6 H_2, 50.0 N_2; per cent combustibles, 49.9; average heating value, 172 B.t.u. per cubic foot.

Another question is this: Is not the efficiency of the gas producer, taken for itself, only a matter of purely theoretical interest? Is not the important matter from a practical standpoint a high efficiency of gas production and utilization combined? For the sake of utilization in the regenerative furnace, is it not better to have hot gas? This is certainly a pertinent practical question. Mr. Smith's answer to it will be found below under the heading: Utilization of Gas in Furnace.

DISTRIBUTION OF GAS

That for distribution purposes cold gas has decided advantages, is evident. The volume is so much smaller and the distributing flues may be made correspondingly small. The gas having been cleaned is free from impurities which would block up the flue and would require to be periodically removed.

But Mr. Smith points out another advantage of purely chemical nature which is liable to be overlooked. "Cold producer gas remains unaltered in composition and is delivered to the furnace in exactly the same physical and chemical state as when generated at the producer. This is by no means true of hot gas," on account of the liability of carbon monoxide decomposing into carbon dioxide and free carbon (forming soot), or of the reaction between methane and water vapor, resulting in the production of carbon dioxide and the liberation of hydrogen. Such reactions reduce the heating value of the gas per cubic foot.

UTILIZATION OF GAS IN FURNACE

"It has been commonly assumed that the thermal energy delivered to a regenerative furnace by the heat carried in hot producer gas contributes directly to the furnace efficiency. Recent careful investigations along this line have indicated that this is by no means universally true. It has been shown both from theoretical considerations and by practical tests that the direct and immediate effect of delivering hot producer gas to the checkers of the regenerative furnace is *to raise the temperature of the stack gases* of the furnace. . . .

"The amount of heat present in the producer gas as sensible heat must certainly be wasted at one point or another. Either it may be removed from the gas at the producer and taken up again in the regenerators at the furnace, with a corresponding lowering of stack temperature, or it may be carried into the regenerators with the producer gas with a corresponding increase of the stack temperature. In either case nothing whatever is contributed to the temperature of the hearth in this way.

"It has been pointed out that by cooling the producer gas, tar and other combustible constituents are precipitated from the gas and lost. This is not by any means the case in the Smith system, since this tar is completely fixed and gasified in the producer, the waste heat contained in the outgoing gases being utilized for this purpose. There being no direct loss in plant efficiency from cooling the producer gas, it remains to be shown that there may be gains in furnace efficiency incident to this process. These gains undoubtedly do exist." First, there is the precipitation of any entrained moisture which would represent a loss and a disturbing element in the furnace operation. Further the process insures more uniform gas quality.

In addition, "with cold gas distribution the supply of gas to the furnace is absolutely and directly under the control of the furnace operator. Small valves of ordinary construction will positively regulate the flow of gas and this will be independent of conditions of stack draft at the furnace or any condition imposed by the requirements of producer operation.

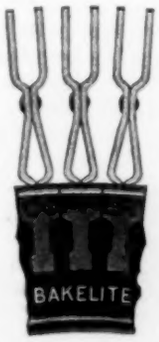
"The aggregate gain to be anticipated from all of the advantages will depend to some extent, of course, on the expertness with which the two types of apparatus are manipulated."

Bakelite for Commutator Insulation

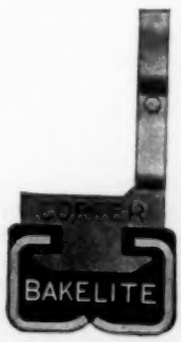
To find out the actual as well as the relative strength of auto starter and lighter commutators, the U. S. Light & Heating Company, of Niagara Falls, recently carried on several tests. The last commutator tested gave by far the best results. This commutator with bakelite molded insulation, proved practically indestructible; it was speeded up to 9060 r.p.m., or 24,600 ft., per minute peripheral speed before going to pieces. As the maximum speed at which such a commutator would be operated in service is only 3500 r.p.m., the factor of safety in the above instance would be 6.7, since the force tending to break the commutator varies as the square of the speed.

COMPLETED COMMUTATOR

It is interesting to compare this test with the previous tests made by this company on commutators made up of brass and steel rings with mica between rings and bars. These constructions proved inferior to the bakelite commutators for the brass commutators went to pieces at 6000 revolutions, while the steel commutators would stand only approximately 8000 revolutions.



CROSS-SECTIONAL VIEW



LONGITUDINAL SECTION, SHOWING INSULATION

Since this test was made there has been a slight change made in the design so that the U. S. Light &

Heating Company are of the opinion that their bakelite commutators will stand 10,000 r.p.m.

The type of commutator tested is shown in the accompanying illustrations, the sections showing the construction of copper segments, steel rings, and bakelite insulation. The commutator complete weighs 8.46 lb., and has an outside diameter over the tangs of 13⅜ in. When tested, the tangs were removed so that the commutator then weighed 7.06 lb. and had an outside diameter of 10⅜ in. This is the diameter at the commutator face.

In order that the commutator, while being tested, would approach service conditions as to temperature, it was heated up to 265 deg. Fahr. before testing; this temperature being higher than would occur in service. Calculations show that the disrupting forces, that is, the force tending to pull the commutator apart, was 15,230 lb. per sq. in. As this was resisted by the tensile strength of the steel rings and bakelite molded insulation, the holding power of the bakelite and steel rings is evidently equal to this figure.

In addition to having the high tensile strength for commutator insulation, bakelite possesses other qualifications; it has high dielectric strength, will not soften under heat up to at least 400 deg. Fahr, and is impervious to oil and moisture.

A Fume and Smoke Recorder, Monitor, and Precipitator, and an Instantaneous Thermostat

BY W. W. STRONG.

During recent years great advances have been made in our knowledge of the electrical properties of gases with the result that a number of new electrical instruments have been developed in connection with furnace operations. An illustration is the electrical precipitator* for removing fumes and smoke from gases. A new type of apparatus is the fume, dust and smoke recorder and monitor.

The Recorder

The fume, dust and smoke recorder is an apparatus designed to register the amount of fumes, dust or smoke in gases. At the same time it may be made to automatically regulate other kinds of apparatus. The mode of making records may include the plotting of a curve on a paper drum or integrating the total time that fumes or smoke of a given density have been emitted.

In the case of smoke many city ordinances permit a few minutes (say six) of smoke emission per hour. The integrating recorder gives the total time in a given interval that the stack has emitted smoke exceeding a certain density. The stack may smoke 3 minutes now, 7 minutes later, 8 minutes later, etc., and the recorder is adjusted so that a watch or clock runs during the smoking periods. In the above example it runs $3 + 7 + 8 = 18$ minutes.

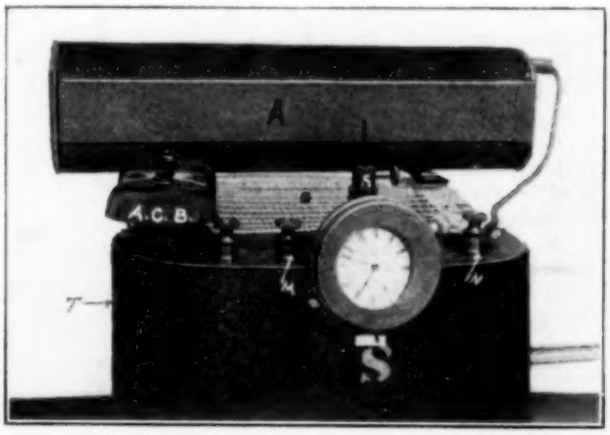
The watch or clock face can be placed so as to be seen by the furnace operator so that he knows what the character of the fume or smoke emission of the furnace stack is at any time. The recorder may be of a portable or stationary type.

The operation of the fume and smoke recorder is very simple. An electrical discharage is given the opportunity of either flowing between electrodes forming an air-gap in the fume or smoke stack or flowing into a condenser and charging it. In the figure a portable recorder is shown. The main part of the apparatus is a step-up transformer T of small current-consuming capacity. The terminals of the transformer are connected in parallel to the stack gap and a condenser in the upper part of the apparatus. By proper setting the condenser is charged whenever the fumes or smoke in the stack exceeds a certain predetermined density depeneding on the length of the gaps. When the condenser is charged the watch or clock is started. In the figure the watch is shown. The only adjustment to be made is that on a spring S holding one of the condenser plates.

It is thus seen that the fume and smoke recorder is very simple in operation, contains no moving parts except the watch and the lever which starts and stops the watch. M and N are binding posts which can be connected to any 110-volt 60-cycle lamp socket. The energy consumed is about 80 or 100 watts. No chemicals are used. The apparatus can be placed in any convenient place and requires practically no attention.

The Monitor

The fume and smoke monitor is essentially the same in its action as the recorder with the difference that in this case an electric circuit is opened or closed instead of a watch being started or stopped. In this way bells, lighted signs and other indicating apparatus may be



FUME, DUST AND SMOKE RECORDER

operated. The value of the monitor lies in part in the fact that its action is instantaneous so that the furnace operator can immediately remedy conditions. In the case of a coal furnace the firemen can immediately change the conditions so that smoking shall cease.

In the figures A C B is a bell which attracts attention to the illuminated sign A. This sign is behind a crown glass screen and contains the lettering "Fuming" or "Smoking" and any suitable directions. The figure represents a combined portable monitor and recorder.

In the case of the monitor the only part requiring any attention is that of the contact points held by the spring S. As the contact points wear away the spring should be slightly lowered. By using tungsten or similar metal the wearing away of the contact points is small.

The Precipitator

The writer has developed a method* of precipitating any kind of fumes, dust or smoke by the use of an electrical corona discharge. This method is probably the most efficient way of precipitating fumes, dust and smoke under many commercial conditions. In the above figure the apparatus can be used so as to precipitate the fumes, dust or smoke if the quantity of

*See Proc. A. I. E. E., June 27, 1913, *Journ.* Franklin Inst., Sept., 1912.

**Journ.* Franklin Inst., Sept., 1912: Proc. Am. Inst. Elec. Eng., June 27, 1913.

gas is small. An instrument of this type will handle in the neighborhood of 80 or 100 cu. ft. of gas per minute. An instrument of this kind is very convenient for precipitating any kind of fumes or smoke in small quantities. Very fine smoke such as cigarette smoke is precipitated beautifully.

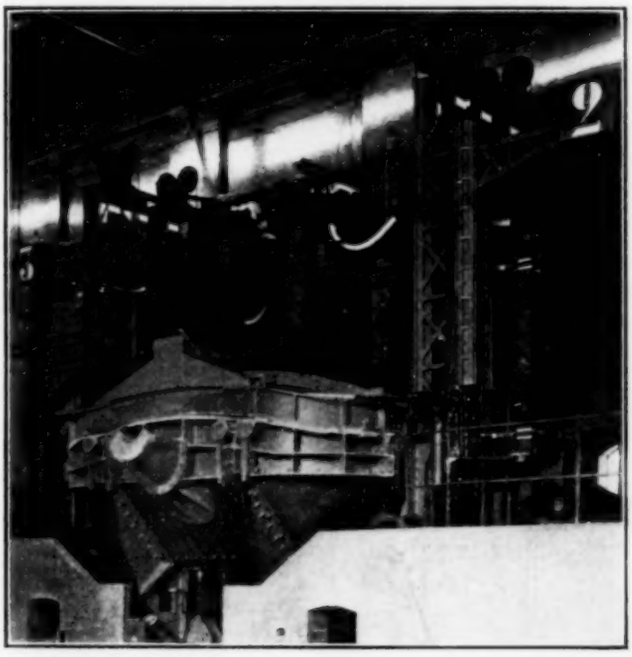
An Instantaneous Thermostat

In the case of ordinary thermometers, thermopiles, pyrometers, etc., there is a certain degree of sluggishness. This sluggishness is greatly increased by the fact that the active thermal detecting parts are usually enclosed in a protecting case which is more or less heat-resisting. In the case of my recorder and monitor there is no case of any kind about the "stack" electrodes so that the recorder or monitor indicates almost instantaneously when the conditions in the gap change.

Under certain conditions as, for example, the intermittent existence of flame or hot gases in the gap, the monitor apparatus can be adjusted to act as a practically "instantaneous" thermostat. The sensitiveness and quickness of action of purely electrical circuits is well known and as the flame or hot gas is the region through which the electrical discharge itself takes place it is easily seen how nearly instantaneous its action can be.

Electric Steel for the French Army and Navy

The Cie. des Forges & Acières Electriques, M. Paul Girod, at Ugine, Savoie, France, is reported to be working busily day and night its large electric furnace plant for the production of special steels for the French army and navy. The accompanying illustration shows the latest addition to the steel-making equipment of this plant. It is a Girod furnace capable of melting up to 25 tons of cold charges of scrap iron and steel.



TWENTY-FIVE-TON GIROD ELECTRIC STEEL FURNACE

The plant has been remodeled and now contains two Girod electric furnaces of 2½ tons capacity each; two Girod furnaces of 10 to 12 tons capacity each, and one furnace, as shown above, with a capacity up to 25 tons of cold charge.

A separate plant in the same town produces large quantities of ferro alloys by means of the electric furnace process.

Suspension Type Storage Bins

The design of storage bins for ore and similar material is an item in mill and smelter construction that requires more careful consideration than it sometimes receives. Efficiency and economy in operation require that such bins should discharge their contents readily without resort to shoveling or mechanical means for emptying them; and the design should take into consideration the angle of repose unit weight and size of the material to be handled. The first cost of the structure should be as low as possible but should not be sacrificed to low cost of maintenance; neither should the structure be subject to heavy depreciation.

A storage bin embodying these ideal features is the Baker suspension type manufactured by Arthur G. McKee, of Cleveland, O. As shown in Fig. 1 the bin combines the principles of the suspension and hopper types,

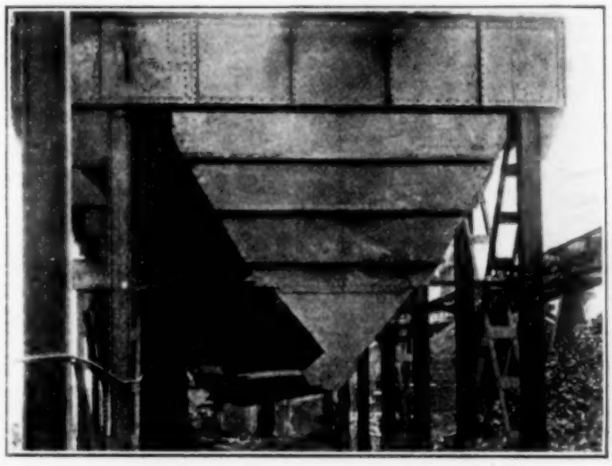


FIG. 1—SUSPENSION TYPE STORAGE BINS

the suspension principle being utilized in the support of the structure and the hopper in the design of the bin bottom. This combination makes possible a slope of sides and bottom greater than the angle of repose of the contents, thus insuring free flow and complete discharge.

A variety of materials can be used in the construction of these bins—wood, concrete or steel, or a combination. The suspension rods and bottoms are built in interchangeable units, thus facilitating erection. One type of bin lining, suitable for coal and ash, is concrete laid on asbestosteel, which is sheet metal with a protective coating of asphaltum covered with asbestos. In another type, concrete slabs 2½ to 4 in. thick form the lining. Wooden lining also may be used for suitable purposes.

For the storage of ore and similar abrasive materials, the bottoms are of steel throughout, made in unit lengths equal to the spaces between supporting bents. The discharge outlet is continuous for the entire length of the bin, and the discharge of material is governed by a continuous series of quadrant gates that may be operated mechanically or by hand. The space beneath the bins is unobstructed, and is available for handling the discharged material. The entire design is flexible, and the bin may be enlarged by adding new units.

The Bristol Company, of Waterbury, Conn., celebrates this year the twenty-fifth anniversary of its foundation. Its plant has grown at the rate of doubling the floor space once every five years. The growth of the business has been especially large during the last six years, since in 1908 the president of the company, Mr. Wm. H. Bristol, again took up the general management.

An Adiabatic Calorimeter

The calorimeters in general use are subject to many errors, namely those of radiation through the surrounding wall, of conduction through the metallic parts and the thermometer, and those due to the inaccuracy of the thermometer readings.

The following description of the Riche adiabatic calorimeter deals with an attempt to eliminate all these errors, through the use of a *vacuum cup* with a suitable covering, proper precaution having been taken to insulate the different parts.

Description of Apparatus.—In all calorimetric work the rise in temperature, multiplied by the quantity of water affected, gives the calories directly, provided there is no loss or gain in heat. Fig. 1 is a sectional sketch of the bomb and calorimeter, which has been designed. It consists of a bomb, *a*, which may be of any type; of a vacuum cup, *b*, containing water; a stirrer, *j*, and a thermometer, *T*. The stirrer is of the screw propeller type, which is very efficient. The vacuum cup is of standard size, 14 cm. wide, 30 cm. high, inside measurements, and was obtained through the Vereinigte Fabriken f. Laboratoriumsbedarf, Berlin, Germany.

The bomb is of the Mahler-Kroeker porcelain type and should last for 8000 combustions; and, inasmuch as it has two outlets, 4-5 determination of carbon may be made. The support for the bomb is a hinged ring, *c*, supported by two brass rods connected with the cover. The rods are insulated by passing them through hard rubber, *m*, and a hard rubber cap is screwed on the end of each rod.

To prevent any possible heat loss from the vacuum cup, it is surrounded by an oak box, *w*, lined with 1-in. pressed cork, *o*, glued to the wood. On the cover, in addition to the cork, is glued a piece of hair felt, *f*, ½ in. in thickness, effecting a tight joint with the top of the vacuum cup.

A hinged door in the front facilitates the handling of the vacuum cup and the cover is raised and lowered by means of telescope tubes, thus giving opportunity to place the bomb in the split ring and to adjust the ignition wires. After the cover is lowered the thermometer is placed in position through a hole in the cover, into which is screwed a brass tube to support and protect it.

Method of Making a Combustion.—The substance to be burned is prepared, weighed and placed in the bomb, which, after being charged with 30 to 40 atmospheres of oxygen, is then placed in the split ring and the wires connected. The water in the vacuum cup is brought to any temperature within plus or minus 5.0° of the room temperature, the cup is then placed in position, the door closed and the top lowered. The thermometer is adjusted and the motor started. Readings are then taken until the temperature of the water becomes constant. The heat absorption is complete when the thermometer shows a constant temperature for three successive minutes.

Temperature equilibrium having been established, the bomb is removed, opened and rinsed with water, and the rinsings are titrated with one-tenth normal alkali for nitric acid, using litmus as an indicator.

Method of Ignition.—Ignition of the substance in the bomb is accomplished by a current from three two-volt storage cells, which first passes through a 3-ampere fuse wire, in series with a platinum wire within the bomb itself. The platinum wire is connected with the substance to be burned by means of a linen thread of sufficient size to secure ignition. The fuse assures the constancy of the heat ignition.

The Need of Exact Determinations.—Whereas other types of the calorimeter require frequently repeated readings and a consequently complicated system of calculations because of imperfect insulation, the Riche calorimeter needs only minute readings. It requires from three to five minutes for the temperature of the water to become neutral and stationary. The operator may ignite his material and then do anything that he pleases during the short interval that follows the final reading.

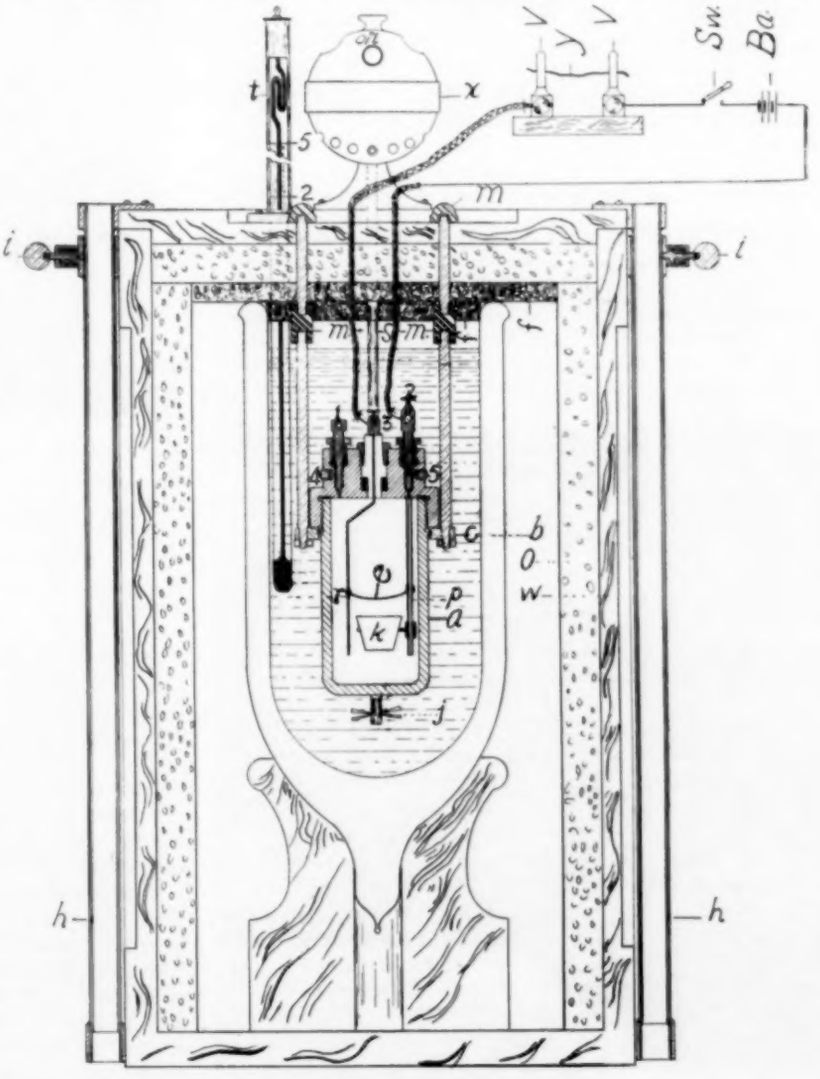


FIG. 1—ADIABATIC CALORIMETER

Calculation of Results.—The reading at ignition is taken as the initial reading. This subtracted from the final reading gives the total rise. This rise multiplied by the weight of water (plus the hydrothermal equivalent of the apparatus) gives the total number of calories liberated. From this is taken the heat resulting from the ignition, and the nitric acid formed. This result,

divided by the weight of substance, gives the calories for the unit of material oxidized.

The Riche calorimeter, therefore, saves from 50 to 75 per cent. of the operator's time. To this saving of time there is added the perfection of the entire calorimeter device. The calorimeter as an established laboratory device will soon be employed generally in connection with the large consumption of all fuels, foods and commercial products, the value of which depends upon their heat contents.

The Metal Spray Process

The Schoop spray process for the production of metallic coatings is well known to our readers from two articles of the inventor, Mr. M. U. Schoop in Zurich, Switzerland, published in our Vol. VIII, p. 404, (1910) and Vol. XI, p. 89, (1913).

The process has naturally been the subject of much speculation and inquiry since it appeared in Europe. Its recent improvements, now protected in the United States, and the acquiring of rights for this country by the Metals Coating Company of America, People's Gas Building, Chicago, make it possible for us to publish some further details of its commercial applications.

The corporation now owning all the United States rights of Schoop and other European inventors already possessed the basic patent, which controls impacting of metal irrespective of the nature of the apparatus used, and the company is therefore in a position to utilize in metal spraying a group of inventions no one of which would have sufficed for the present stage of commercial development which the process has attained. Mr. John Calder is the president of the Metals Coating Company of America.

As described in detail in Mr. Schoop's former articles, the principal apparatus used in the spray process is a "pistol." Into one side of it a cold metal wire on a reel is pulled in continuously at a uniform rate. Within the pistol the metal wire is melted by a hydrogen-oxygen flame and by means of a violent air-blast the melted metal is "fired" out of the pistol in form of a very fine spray at a very high velocity.

If the nozzle from which the metal spray issues is pointed from a distance of 5 in. at the surface of various objects of metal, wood, paper, stone, clay, cement, cloth, silk, glass and other substances, the surface receiving the spray becomes coated with a dense adherent film of the metal composing the wire fed into the pistol. Elemental and alloyed metals may be handled with equal facility. Lead, tin, zinc, aluminium, copper, brass, bronze, German silver, etc., may be fed into the instrument at will and deposited freely in coatings from 0.001 in. upward in thickness.

The temperature of the molten metal spray at the nozzle may be varied according to the wire used from 700 deg. F. to 2000 deg. F., yet 5 in. away none of the objects coated is injured or altered in the act of metallizing them. Matches held in the zinc spray are immediately coated over without ignition, and the thinnest paper and wood receive the impacting particles into their pores without charring. Brass issuing at 1550 deg. F. from the nozzle is deposited on the thinnest silk fabrics without damaging the textile.

In considering what occurs in the Schoop process it is necessary to bear in mind a singular fact: the sprayed metal moves only 6 in. between its points of fusion and the object to be coated, yet it does *not* reach the object in a molten state. It even possesses so low a temperature that it can be safely directed upon the hand for a moment without injury and can be continuously impacted upon materials such as cloth, paper, wood and even celluloid, which would be immediately consumed by the heat of any molten metal. A box of matches can be coated all over to form a seamless metal case without a single match being ignited.

The reason is that the gaseous medium used is much larger in volume at any moment than the drop it has pulverized and is carrying and the gas is expanding so rapidly that its temperature is far lower than that of the spray. A rapid exchange of heat therefore takes place between them which consolidates the molten particles and gives them a temperature far below the melting point. If the particles arrived in a liquid state at the base with the observed velocity of 3000 ft. a second they would simply splash on the plate and largely rebound. As a matter of fact they impact and interpenetrate freely and the later bombarding particles unite with the earlier ones to form homogeneous compact bodies. In accounting for the observed action of the Schoop spray at the receiving base, it is supposed that the cooled particles of metal just before impinging with great velocity on a hard surface are in an abnormal physical condition. Due to the heat of collision they pass directly into a vapor which condenses and solidifies on the relatively cold receiving body, penetrating by osmotic pressure the superficial pores of the base where any affinity for the latter exists and, otherwise, driven in by the pressure behind it.

In either case it condenses and solidifies after penetration and is effectively dovetailed into the base. The hammering and bombardment of the solidified first coat by the minute succeeding particles is practically a process of cold working. The entrained particles liquefy and solidify so rapidly that the metal has not time to return to its natural crystalline state.

The theory just outlined seems to be supported by examinations of the sprayed deposits, for the structure of the metal coatings and of the whole bodies produced by the Schoop process is always found to be amorphous and vitreous throughout.

This characteristic is of great importance to many large metal industries.

The spray nozzle is provided with three hose pipes which lead oxygen, hydrogen, and air from their respective containers to the burner tube and blast nozzle which are concentric. The cost of operating the Schoop process in the United States has been carefully ascertained through experience with the appliance during the last six months. The seven metals most commonly used for protecting or decorating surfaces are lead, zinc, aluminium, brass, German silver, bronze and copper. When the gases are purchased in small quantities in the usual containers, the cost of spraying lead including the cost of wire, compressed air and labor, is between 1 and 2 cents a square foot and 1 lb. of lead can be sprayed in less than a minute. The other metal coatings vary with the initial price of raw material and its relative hardness.

Where concerns operate a number of pistols they usually generate their own gases or purchase them on a wholesale basis thereby effecting considerable saving in the cost of operating the process.

The spray process may be applied in two entirely different ways—namely, the coating produced may be made detachable or adherent. Accordingly the applications are different.

By means of the detachable sprayed coatings it is possible to copy in metal any metallic, cement or composition object.

On the other hand, permanent coatings are used either for decorative purposes or to preserve surfaces from decay in the atmosphere or from moisture or any form of chemical attack.

Every kind of hardware of iron, steel or alloy at present enameled or dipped or coated with glazes can

be plated cheaply with aluminium, tin, or any desired metal. Cooking vessels can be so lined and give better wear than all-aluminium products, at much less cost; steel tanks can be perfectly protected by a lead coating, and vessels liable to rust or to the action of chemicals can be lined cheaply with any desired protection and repaired as quickly.

Every kind of domestic hardware, whether of iron, steel, and any other simple metal, or of alloys, can be coated with a layer of any selected metal, and glass enamel and glazes can also be rapidly applied as lining by the same implements and process. Stoves and utensils of all kinds can be rapidly decorated and protected by sprayed nickel or any other metal desired.

Cooking vessels, both domestic and for manufacture of foodstuffs, can be lined with any metal, and repairing of linings is a rapid, simple process and very inexpensive.

Beer kegs, for instance, requiring frequent and expensive treatment with pitch, can be readily coated inside with aluminium, giving a clean and durable protection, and wines and liquids now subject to leakage and loss in casks can be completely protected by suitable lining in the containers. Brass cloth for chemical plants can be lead sprayed for protection; cast iron pots for alcohol, acid and other stills can be lead lined and all forms of pipes, tanks, reservoirs and containers for acids, oils or chemicals can be protected quickly with any required metal.

Calico printers' rolls can be coated rapidly with homogeneous and adherent copper.

Iron and steel structural work can be provided with a permanent rust-resisting metal coating.

Much of the metal welding can be carried out by the spray process which neither heats nor distorts the object under treatment and is relatively inexpensive.

Vitreosil

"Vitreosil Apparatus for Chemical Laboratories" is the title of an interesting neatly illustrated pamphlet just issued by the Thermal Syndicate, Ltd., of New York. It contains notes on the various laboratory ware made from vitreosil (fused silica), such as combustion tubes, pyrometer tubes, test tubes, triangles, plates, rods, casseroles, dishes, crucibles, flasks, muffles, trays, etc. An interesting bibliography is added.

In the introduction the general physical and chemical properties of vitreosil are discussed. Vitreosil is 99.8 per cent pure SiO_2. Its coefficient of expansion is 0.00000059, that is, it is so small that vitreosil may be subjected to rapid changes of temperature without danger of breakage. It should not be exposed, however, *continuously* to temperatures over 1200 deg. C.

Vitreosil is absolutely insoluble in water. It is unaffected by mineral or organic acids with the exception of hydrofluoric, and at high temperatures, phosphoric acid. The action of phosphoric acid only commences at 400 deg. C., so that for all ordinary work with this acid it can be safely used. Aqua regia or a mixture of chromic and sulphuric acid do not attack vitreosil at any temperature.

Vitreosil resists high temperatures without injury and its insulating value decreases much more slowly with increasing temperatures than is the case with glass or porcelain. These unique properties permit the successful employment of vitreosil as a high-temperature insulator where other ceramic materials are unsatisfactory. It offers the further advantage that moisture does not readily condense on its surface. The translucency of the glazed quality is a valuable property when the material is used in the construction of electrical heating apparatus.

Niagara Falls Meeting of American Electrochemical Society

The twenty-sixth general meeting of the American Electrochemical Society will be held in Niagara Falls from Thursday to Saturday, October 1 to 3, 1914. Headquarters will be at the Clifton Hotel.

The Board of Directors will meet on Wednesday evening, September 30.

Sessions for reading and discussion of papers on Thursday morning, October 1, and Friday afternoon, October 2 at the Clifton Hotel.

Symposium at the FitzGerald Laboratories, Highland and Vermont Avenues, Niagara Falls, N. Y., Saturday, October 3, morning and afternoon.

Excursions and Entertainments:

Thursday afternoon, October 1. Excursion to Foster's Flats, Niagara Gorge, a spot not much visited by or well known to tourists. A local authority on the flora, fauna and history of the spot will be present and give information of interest. Light refreshments. This event will be interchangeable with the Professional Session scheduled for Friday afternoon in the event of unfavorable weather on Thursday.

Thursday evening. Smoker, "The Home of Section Q." The section has placed a strict censorship on all communications from Niagara Falls relating to the program.

Friday morning, October 2. Visits to plants and power houses. A number of interesting plant visits are being arranged and a full list will be announced later. Besides the power houses, the International Acheson Graphite Company and the Niagara Alkali Company, under some restrictions, will be visited. A much larger number of plants will be open to visitors than ever before, this being one of the unusual attractions of the meeting.

Friday Evening. Subscription dinner. No speeches. Experimental lecture following.

Saturday Evening, October 3. Kommers at Niagara Club or Fort Schlosser Club.

A feature of the meeting will be an Experimental Symposium on "The Practical Side of Electrochemical Investigation," occupying two sessions on Saturday, and consisting of a number of demonstrations of methods and apparatus. Promises of participation have already been secured from Mr. F. A. J. FitzGerald, Research Laboratory General Electric Company, Research Laboratory Westinghouse Electric and Manufacturing Company, Mr. L. E. Saunders, Mr. A. T. Hinckley, Mr. Max Mauran, Dr. Carl Hering and Mr. Lynn Bradley, and others.

The symposium will be held in the FitzGerald Laboratories, where the excellent facilities available will permit a display of extreme interest and of very diversified character.

Ladies Arrangements:

All sessions will be open to ladies. On Thursday evening an entertainment will be provided, while members are attending the smoker. The Foster's Flats excursion will be especially interesting to ladies and they are urged to make the trip.

The complete program of papers will be published in our next issue.

The **Johnson Electric Smelting, Inc.,** plant will be located probably at Hamilton, Ill., opposite Keokuk on the banks of the Mississippi River. It has been found impossible to procure a suitable site on the Iowa side of the river. The Illinois side is much better from standpoint of favorable freight rates on spelter, copper matte or base lead bullion to New York, Pittsburgh and Chicago. Freight on ores is same from West on either side.

Personal

Mr. F. T. Boyer, formerly connected with the National Lead Company at their Collier works in St. Louis, Mo., is now superintendent of the Philadelphia smelting works of Merchant & Evans Company.

Mr. J. M. Callow, of the General Engineering Co., Salt Lake City, has returned west from a trip to New York City.

Dr. **Hector R. Carveth,** works manager of the Niagara Electrochemical Company, tried to get to Europe on the steamship *Kronprinzessin Cecilie* and failed.

Mr. **H. C. Clark,** formerly Ohio agent of the E. F. Houghton Company, is now connected with the Stupakoff Laboratories, pyrometer manufacturers, of Pittsburgh, Pa.

Mr. **George E. Collins** has returned to Denver from London, where he has been on professional business.

Dr. **Stuart Croasdale,** of Denver, is engaged in professional work in British Columbia.

Mr. **F. H. Emerson** has been appointed Boston district manager of the Bristol Company, with headquarters in the Old South Building.

Mr. **C. M. Eye** has been making metallurgical tests at the experimental plant of the Colorado School of Mines, Golden, Col., prior to designing and erecting a cyanide mill for the Benguet Consolidated Company, Bagui, Philippine Islands.

Mr. **Jacob Hasslacher** is convalescing at his summer home in Elka Park, N. Y. On the 8th of August the silver anniversary of the founding of the park was celebrated, of which Mr. Hasslacher is the president. Since Mr. Hasslacher was not well enough to attend the banquet and other festivities, the members and guests of the Park honored their president with an ovation and a long torchlight parade headed by a large brass band. More than two hundred took part, including many engineers and chemists.

Mr. H. C. Hoover has accepted the temporary chairmanship of Camp Bird, Ltd., and the Santa Gertrudis Co. Mr. **R. J. Frecheville** has resigned his position as director of the companies and assumes the chairmanship of the technical committee. Messrs. **F. A. Govett** and **F. H. Hamilton** have joined the boards of both companies, and Messrs. **Norman Craig** and **George de Pass** have joined the Santa Gertrudis and Camp Bird boards, respectively.

Mr. **D. C. Jackling** is making one of his periodical trips of inspection to Alaska. From Seattle he will be accompanied by a party of guests on his yacht the *Cyprus*.

Mr. **Lorin Kemp,** until recently in charge of cyanide mills of the North Star Mines Co., Grass Valley, Cal., has resigned to accept a position in Chile.

Mr. **D. J. Lewis, Jr.**, consulting engineer, has just closed a contract with the Cape Cruz Company of New York to furnish for their sugar factory a trap system to collect from their juice heaters, evaporators, vacuum pans and live steam drips, a maximum amount of 100,000 pounds of condensation per hour and return it automatically to the boilers. The pressures will vary on the different devices from zero to 125 pounds. Mr. Lewis was formerly manager of the "Bundy" trap and for three years ending May 1, sales manager and engineer for the Lytton Manufacturing Corporation. He is now associated with Mr. W. J. Wayte, and they are making a specialty of power house, sugar house and chemical works efficiency. Mr. Lewis is sales agent for the Lytton Manufacturing Corporation for New York and New England, and Mr. Wayte is the United States agent for the Watson, Laidlaw & Company, Limited, of Glasgow, Scotland, manufacturers of centrifugal machinery.

Mr. **W. B. Mangan** is manager, and Mr. **W. N. Rossberg** superintendent of the Timber Butte Milling Co., Senator Clark's new zinc concentrator at Butte, Mont.

Mr. **L. M. Marshall** has resigned as assistant general manager of A. J. Haws & Sons, refractory manufacturers, Johnston, Pa. Prior to six months ago Mr. Marshall was chief engineer of the Cambria Steel Company.

Mr. **Kirby Thomas** was in Denver recently on his way to Colorado mining districts on professional business.

Mr. **H. N. Thomson,** formerly with the Anaconda and International smelting companies is at Clarkdale, Ariz., with the United Verde Copper Co.

Mr. **Samuel S. Webber,** of Trenton, N. J., has resigned his position as chief engineer for the Trenton plant of the American Steel & Wire Co.

Mr. **F. S. Youtsey,** of Denver, Col., is at St. Francois, Mo., erecting a mill for the St. Louis Smelting & Refining Co.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

AQUEOUS BATH (ELECTROPLATING) *Continued*

537,403, April 9, 1895, George D. Burton, of Boston, Mass.

Relates to the extraction of oil and grease from wool. Within a suitable tank, holding about thirty gallons of solution, is placed preferably a solution of bichromate of potash, of specific gravity 1.05; or a solution of five pounds chloride of sodium, three ounces of sulfuric acid, and twenty gallons of water may be used. The wool is now immersed, at first a current of sixty-five amperes at two hundred and twenty volts is passed between electrodes of preferably a foot square. When the desired temperature is reached, the current is reduced to about twenty amperes. The preferred temperature is about 155 deg. F. The oil or grease rises to the surface of the liquid and may be removed; after the wool is sufficiently cleaned, it is removed and washed.

554,795, February 18, 1896, Dexter Reynolds, of Evansville, Indiana, Assignor, by direct and mesne assignments, to T. M. Steinmetz, M. A. Tobin, August Holthaus, and George P. Heckel, of St. Louis, Mo.

Relates to an apparatus to be used in laundering, and is designed to thoroughly cleanse and disinfect wearing-apparel and other fabrics of all disease germs without injury to such fabrics. The apparatus consists of two electrodes, for example zinc, placed in the bottom of the tub, and connected by insulated wires to a suitable source of current. The wires pass through V-shaped flexible tubes that are inserted through the handles of the tub. By subjecting apparel or other fabrics, such as bed-clothes, surgical cloths, bandages, sponges, etc., to immersion in a body of water or other laundering liquid charged with and decomposed by electricity, they are not only thoroughly cleansed, but all disease germs of whatever nature are absorbed and destroyed, thus saving such apparel or fabrics from destruction and rendering them capable of further use. The apparatus is also applicable for sterilizing liquids.

558,176, April 14, 1896, Philip Huber, of Saginaw, Mich.

Relates to an apparatus for decomposing water by electrolysis, and consists of a tank in which are placed bottomless jars having outlets at the top, the outlets being connected to suitable gas receivers. In each jar is placed a platinum electrode. The evolved hydrogen and oxygen may be burned in a suitable burner and heat any object desired, the heated object radiating heat to the surrounding space.

558,717, April 21, 1896, Henry L. Brevoort, of Brooklyn, N Y.; Gertrude L. Brevoort, executrix of said Henry L Brevoort, deceased, assignor by direct and mesne assignments, to the Electro Waterproofing & Dye Fixing Company, of New York, N. Y.

Relates to a process for waterproofing various fabrics made of animal or vegetable fibers, such as threads, cords, ropes, string, cotton sheeting, sails for ships, cloth, etc., made of cotton, wool, or silk. The fabric is wet with water, such as city water, preferably neither acid or alkaline, and pressed between two conductors such as plates or rolls, to give a firm contact. The anode is preferably of aluminium or tin, the cathode may be of the same or different metal, or of carbon. In place of aluminium or tin, iron, copper, or silver may be used as the anode, but these may color the fabric; zinc gives fair results; lead, antimony, or bismuth are not desirable as anodes. On passing a direct current through the wet fabric from anode to cathode, with an ameter in circuit, the instrument will at first indicate a sudden rise in current, which will then drop, due presumably to the formation of oxides, and the presence of gases, and then finally rise again; it should be broken when it rises after the preceding drop. If continued after the second rise, the desired object will be defeated and the goods cease to be water-repellent. After the treatment and the fabric is dried, it will be found to be waterproof, or water-repellent, believed to be produced by a metallic oxide formed from the anode, the oxide entering the fabric or its fibers and making them water-repellent. With cotton cloth, voltages from 1 volt to 100 volts have been used, the time of treatment being decreased with the higher voltages. With electrodes of between 2 in. and 3 in. in diameter, using 30 volts and a pressure of about 50 lb. on the electrodes, satisfactory results have been obtained with treatments varying from one second to thirty seconds, preferably about fifteen seconds. In fabrics heavily dressed with soluble matter, the process is not as satisfactory; in fabrics having a dressing or finish containing grease, the water-proofing is difficult because it is difficult to wet the fabric. It is desirable to cover the cathode with a separate piece of cloth when practicing the process.

558,718, April 21, 1896, Henry L. Brevoort, of Brooklyn, N. Y.; Gertrude L. Brevoort, executrix of said Henry L. Brevoort, deceased, assignor, by direct and mesne assignments, to the Electro Waterproofing & Dye Fixing Company, of New York, N. Y.

Relates to the fixing of that class of dyes in which the coloring principle is in solution in the liquid to which the cloth is subjected, and which coloring principle requires a mordant to fix the same in the goods. Such colors may be fixed by subjecting the goods to a direct current after they have been run through the solution containing the coloring principle, the goods being between a metal plate or roller connected as anode, and a carbon or metal plate or roller as cathode. The current is passed through the goods from the anode to the cathode, the water in the fibers is decomposed, and oxygen liberated at the anode, forming an oxide of the metal which enters into chemical combination with the coloring principle contained in the goods, thus fixing the color as though a mordant had been employed in the old way. With different metals, as anodes, different colors may be produced, and different degrees of color can be obtained by varying the concentration of the dye. Each specific material, its thickness, and the dye employed, alter the current conditions, necessary to fix the color. A metal is necessary as the anode, as the oxide of a metal is the fixing agent for the natural color, the oxide being carried into the fiber. The metals best adapted for anodes are aluminium, tin, zinc, lead, copper, iron, and brass. In general, those metals work best whose oxides form with the coloring principle colored salts. An alternating current may be used if metallic electrodes are used on both sides. Engraved plates or rollers may be used as anodes.

Book Reviews

Fabrication de l'Acier. By **H. Noble.** Second edition, revised and enlarged. Large octavo (15½ x 24 cm.), 632 pages, 86 illustrations; price 26.50 francs, in New York $5.30. Paris: H. Dunod & E. Pinat.

The author was a French steel-works superintendent, and his book is a happy combination of theory and practice. It covers only the manufacture of Bessemer and open-hearth steels, omitting entirely crucible and electric-furnace steel. Considering the field covered, we find the chapter on the general properties of steels too brief, but the rest of the book very satisfactory. The author evidently writes directly from his own experience, and is moderate in his theoretical views, yet clear and practical. Large use is made throughout of metallurgical calculations, applied particularly to the thermal phenomena of the steel manufacture. It is unfortunate that the author has, however, neglected the heat of formation of the slags, in each case; some of them are now known nearly enough to be brought into the calculation. This is but a minor criticism on a book full of first-class, first-hand information, of a kind needed by every steel manufacturer, but especially valuable to the makers of Bessemer and open-hearth steel.

Elektrochemisches Praktikum. By Dr. **Erich Muller.** 16 x 22 cm., 224 pages, 73 illustrations; price 8 marks. Dresden and Leipzig: Theodor Steinkopff.

The author is director of the electrochemical laboratory of the Dresden Technischen Hochschule, and his work shows throughout his intimate familiarity with the subject. After describing the sources of current, and apparatus used, the first section covers exercises on fundamental laws, comprising tests of Ohm's law, Faraday's law, conductivity of electrolytes, electromotive forces. The next section deals with separation of metals from solution, under different conditions. A long section comprising 27 exercises then follows, on the preparation of important inorganic compounds, such as caustic alkali, perchlorates, etc. The production of organic reactions is covered in 10 exercises. Electrolysis of fused salts is illustrated by the production of aluminium, magnesium and decomposition of lead chloride; electrothermal processes by the production of carbide ferrochromium and ferrosilicon.

The 69 exercises are fairly well chosen, and always clearly set forth. We would suggest substituting the production of carborundum for that of ferrochromium, since it illustrates a different kind of process; and that of sodium for magnesium, as being more instructive, and valuable for its historical associations.

While the plan and method of presentation are excellent, the choice of the exercises could be improved upon in several instances, as above suggested.